Miscellaneous Paper EL-98-2
October 1998

US Army Corps
of Engineers
Waterways Experiment
Station

Water Quality Modeling for the Napa River 100-Year Flood Control Project

by Ross W. Hall, Mark S. Dortch

19981120 024

Approved For Public Release; Distribution Is Unlimited

Reproduced From
Best Available Copy

DTIC QUALITY INSPECTED 2

Prepared for U.S. Army Engineer District, Sacramento

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

PRINTED ON RECYCLED PAPER

Miscellaneous Paper EL-98-2
October 1998

Water Quality Modeling for the Napa River 100-Year Flood Control Project

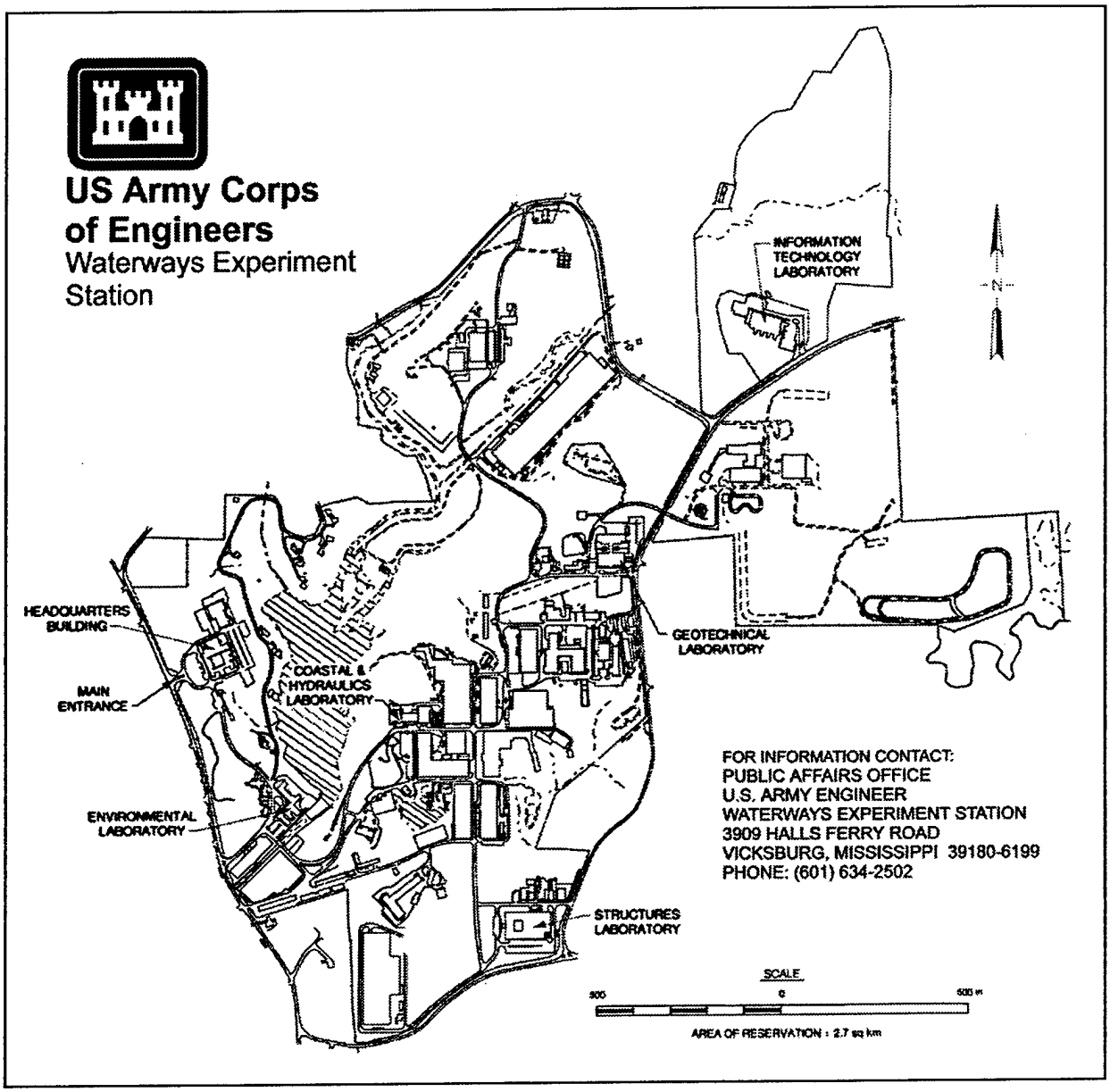
by Ross W. Hall, Mark S. Dortch

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Engineer District,Sacramento
Sacramento, CA 95814-2922



Waterways Experiment Station Cataloging-in-Publication Data

Hall, Ross W.
Water quality modeling for the Napa River 100-Year Flood Control Project / by Ross W. Hall, Mark S. Dortch ; prepared for U.S. Army Engineer District, Sacramento.
56 p. : ill. ; 28 cm. -- (Miscellaneous paper ; EL-98-2)
Includes bibliographic references.
1. Biochemical oxygen demand. 2. Water -- Dissolved oxygen. 3. Napa River (Calif.) 4. Water quality -- California -- Testing. I. Dortch, Mark S. II. United States. Army. Corps of Engineers. Sacramento District. III. U.S. Army Engineer Waterways Experiment Station. IV. Environmental Laboratory (U.S. Army Engineer Waterways Experiment Station) V. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; EL-98-2.
TA7 W34m no.EL-98-2

Contents

Preface vii

1--Introduction 1

The Study System 1
Objective 2
Approach 2

2--Input Data 3

Bathymetry 3
Inflows 3
Inflow Temperatures 4
Inflow Constituent Concentrations 4
Downstream Head Elevations 4
Downstream Head Boundary Constituent Concentrations 6
Meteorological Data 6
Salt Evaporator Leachate 6
Hydrodynamic and Kinetic Coefficients 7
Initial Conditions 7

3--Results 9

Calibration 9
Comparison 10

4--Summary and Conclusions 12

References 14

List of Figures

Figure 1. Napa River and Vicinity Map

Figure 2. Site Map

Figure 3. Napa River flow (Oak Knoll gage), July 1 - September 30, 1994

Figure 4. Carquinez tide gage data, 1994

Figure 5. Carquinez tide gage data, July1 - September 30, 1994

Figure 6. Generated Carquinez tide data, August 10 - September 30, 1994

Figure 7. Existing plus generated tide data, July1 - September 30, 1994

Figure 8. Temperature calibration, August 10, 1994

Figure 9. Temperature calibration, September 6, 1994

Figure 10. Temperature calibration using Travis AFB meteorological data, August 10, 1994

Figure 11. Temperature calibration using Travis AFB meteorological data, September 6, 1994

Figure 12. Surface TSS calibration, August 10, 1994

Figure 13. Bottom TSS calibration, August 10, 1994

Figure 14. Surface TSS calibration, September 6, 1994

Figure 15. Bottom TSS calibration, September 6, 1994

Figure 16. Surface salinity calibration, August 10, 1994

Figure 17. Bottom salinity calibration, August 10, 1994

Figure 18. Surface salinity calibration, September 6, 1994

Figure 19. Bottom salinity calibration, September 6, 1994

Figure 20. DO calibration, August 10, 1994

Figure 21. DO calibration, September 6, 1994

Figure 22. DO calibration (alternate time), August 10, 1994

Figure 23. DO calibration (alternate time), September 6, 1994

Figure 24 Temperature comparison, August 10, 1994

Figure 25. Temperature comparison, September 6, 1994

Figure 26. Surface TSS comparison, August 10, 1994

Figure 27. Bottom TSS comparison, August 10, 1994

Figure 28. Surface TSS comparison, September 6, 1994

Figure 29. Bottom TSS comparison, September 6, 1994

Figure 30. Surface salinity comparison, August 10, 1994

Figure 31. Bottom salinity comparison, August 10, 1994

Figure 32. Surface salinity comparison, September 6, 1994

Figure 33. Bottom salinity comparison, September 6, 1994

Figure 34. DO comparison, August 10, 1994

Figure 35. DO comparison, September 6, 1994

Figure 36. Average DO comparison, August 1 - September 30, 1994

List of Tables

Table 1. River Mile of Selected Features

Table 2. Specified Upstream Inflow Temperatures

Table 3. Harmonic Analysis by Program Harmony

Table 4. Important Hydrodynamic and Kinetic Coefficients

Table 5. Sediment Oxygen Demand (SOD) Values Used

Preface

The numerical water quality study for the Napa River 100-year flood control project was conducted at the U.S. Army Engineer Waterways Experiment Station (WES) for the U.S. Army Engineer District, Sacramento.

The study was conducted by Mr. Ross W. Hall of the Water Quality and Contaminant Modeling Branch (WQCMB), Environmental Processes and Effects Division (EPED), Environmental Laboratory (EL), WES. Dr. Mark S. Dortch, Chief, WQCMB, provided direct supervision and report review. General supervision was provided by Dr. Richard E. Price (EPED), Chief, EPED, and Dr. John Harrison, Director, EL. Technical assistance by Thomas M. Cole, Fred C. Herrmann, and Dorothy H. Tillman is gratefully acknowledged.

Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

This report should be cited as follows:

Hall, R. W., and Dortch, M. S. (1998). "Water Quality Modeling for the Napa River 100-Year Flood Control Project," Miscellaneous Paper EL-98-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

1 Introduction

The Study System

The Napa River drainage basin, located just north of San Pablo Bay, is about 50 miles long on a north-south axis, ranges from five to ten miles in width, and covers approximately 426 square miles. The Napa River originates near Mount St. Helena and empties into Mare Island Straight which flows into the tidal marshlands and sloughs of San Pablo Bay (Figure 1).

The Napa River is navigable from San Pablo Bay to Third Street in downtown Napa, a distance of 18.7 miles. The navigation channel is 100 feet wide and 15 feet (-18 NGVD) deep for the first 15.4 miles and 70 feet wide and 10 feet (-13 NGVD) deep for the remaining 3.3 miles. Tidal influences extend from San Pablo Bay through downtown Napa to upstream of Trancas Street. The tidal range for the Napa River is about 7 feet and ranges from -2.9 NGVD to about 3.8 NGVD. The river has a large oxbow area within the city of Napa (Figure 2). Table 1 summarizes the location of features to River Mile (RM). The study defines RM 0 at the Carquinez Strait Light Buoy. The RM specification used in this study is 4 miles greater than that specified on the U.S. Department of the Interior Geological Survey quadrangle maps of the Napa River. On the CUTTINGS WHARF, CALIF QUADRANGLE, the location printed as RM 1 corresponds to RM 5.0 in this study.

The Napa River is susceptible to floods damaging homes and businesses in Napa. The flood project, from Third Street downstream to Kennedy Park, increases the channel conveyance needed to carry flood flows. Increased conveyance is achieved by excavating and widening the channel above the mean-tide level. The channel modifications create a floodway through the city. The constructed floodway will include a tidal terrace set at elevation 0.7 NGVD and a flood terrace set at the elevation of the two year flood. By keeping excavation above the low-tide level and maintaining the existing river channel below the low tide level, impacts to water quality are expected to be minimized. The oxbow has a bottom elevation below low tide level. The dry bypass (Figure 2) is excavated above low-tide level. The dry bypass passes high flows while maintaining low flows in the oxbow, thus minimizing water quality concerns.

Table 1 River Mile of Selected Features	
Feature	River Mile
Mouth of Napa River	0.0
End of 100 foot wide navigation channel	15.4
Beginning of flood control project	15.6
Imola Avenue	17.3
Third Street End of Navigation Channel Start Bypass Channel	18.7
Trancas Road End of Flood Control Project	21.3

Objective

The objective of the study is to compare water quality between existing and project conditions. The period covered by the study are the critical months for water quality of late summer and early autumn. July 1 through September 30, 1994, was used as the time period for both calibration and comparison. The only difference between existing and project conditions is the channel bathymetry between RM 19.1 downstream to RM 15.6.

Approach

The two-dimensional hydrodynamic and water quality model CE-QUAL-W2 was selected for the study. Use of the code is appropriate where lateral homogeneity can be assumed and longitudinal and vertical temperature, salinity, or constituent gradients occur. CE-QUAL-W2 generates time-varying velocity, temperature, salinity, water quality constituent fields, and surface elevations on a longitudinal and vertical grid (Cole and Buchak 1995).

The study consisted of the following steps: (1) calibration to existing data and (2) comparison of existing and project conditions. Water quality consituents simulated include temperature, total suspended solids (TSS), salinity, dissolved oxygen (DO), and biochemical oxygen demand (BOD). Water quality constituents simulated did not include nutrients and algae because data were not available for these variables. The period of simulation extended from July 1, 1994, through September 30, 1994.

2 Input Data

Bathymetry

The Napa River extending from RM -0.4 to RM 21.4 was represented by 70 horizontal segments, each 506 meters in length, and 23 vertical layers, each 0.5 meters thick. The computational grid consists of boundary cells at the upstream, downstream, top, and bottom of the computational grid. Therefore, the computational grid is referred to as a 72 by 25 grid. The first active segment is numbered 2, and the last active segment is numbered 71. Active cells are defined with a non-zero width. Within a segment, active cells have a non-zero width from layer 2 to the bottom.

The differences between existing conditions and project conditions consist entirely of bathymetry changes. The grid geometry is specified in CE-QUAL-W2 by three parameters: (1) longitudinal spacing; (2) vertical spacing; and (3) cross-sectional widths. Both existing and project conditions use the same longitudinal and vertical spacing; the bathymetry changes between existing and project conditions are cross-section widths between RM 15.6 and 19.1. The U.S. Army Engineer District, Sacramento, CE, (CESPK) provided cross-section widths for existing and project conditions.

Inflows

The CESPK provided U.S. Geological Survey (USGS) Oak Knoll flow gage data for October 1, 1993, through September 30, 1996. The Oak Knoll gage (USGS Station Number 11458000) is located 5 miles north of Napa, California. The gage is located about 3.4 miles upstream from the first model segment. The Oak Knoll gage data were used to prepare the inflow file. The gage data were recorded as daily average discharge.

Figure 3 displays measured discharge for the period of simulation, July 1 (Julian Day 182) through September 30 (Julian Day 273), 1994. Examination of Figure 3 reveals very small or near zero flows during the simulation period. For preparation of the inflow file, 1 cfs (0.02832 $m^3 sec^{-1}$) was added to measured flow data to provide a minimum flow of at least 1 cfs at all times. Conductivity measurements, conducted on August 10 and

September 6, 1994, at Trancas Road indicated a freshwater source. The small minimum flow was necessary to reproduce measurements at Trancas Road.

Inflow Temperatures

The inflow temperatures were specified based on observed temperatures measured at the Trancas Road sampling station August 10, 1994, and September 6, 1994 (Table 2).

Table 2
Specified Upstream Inflow Temperatures

Date	Temperature, °C
July 1 - July 15, 1994	25
July 15 - September 30, 1994	24

Inflow Constituent Concentrations

Inflow concentrations were specified for the following chemical constituents: (1) TSS, (2) salinity, (3) DO, and (4) BOD. TSS were set to 10.0 g m^{-3}. Salinity for the inflow constituent file was set to 0.0 ppt. Dissolved oxygen was set to 100 percent saturation for the equilibrium temperatures computed from the Concord/Buchanan meteorological data. BOD was set to 2.6 g m^{-3}. The selected BOD value was the arithmetic average of the two BOD measurements reported for the April 1, 1996, water quality survey for RM 15 and RM 17.25. No other BOD measurements were available. Slightly higher BOD values (e.g. 1 to 2 g m^{-3} higher) could occur in summer, but the model was relatively insensitive to these adjustments.

Downstream Head Elevations

The downstream head elevations were based on 15-minute continuous records of water surface elevation in the Carquinez Strait by the USGS (Station ID 182130). Figure 4 displays the data supplied by the USGS. The surface elevations were recorded in feet as NGVD plus 10 feet. Examination of Figure 4 reveals data gaps between Julian Day 170 (June 19) and Julian Day 181 (June 30) and between Julian Day 227 (August 14) and Julian Day 257 (September 13). The gap between August 14 and September 13 corresponds to 31 days during the simulation period and importantly includes September 6. September 6 is the date for which a Napa River sampling survey was conducted. Figure 5 displays available Carquinez water level data during the study period. A procedure was adopted to fill in the missing data between August 14 and September 13.

The tidal record between July 1 through August 14 was used to fit tidal constituents so that the fitted tidal constituents could be used to generate tidal data between August 14 and September 13. The tidal record consisted of 4270 points. The program HARMONY, supplied by the Coastal and Hydraulic Laboratory, WES, was used. Table 3 summarizes the results of the program HARMONY. The RMS value of 0.437 feet indicates that influences other than astronomical affect observed tidal heights. Other possible influences include river flow and wind effects. The fitted tidal constituents were used to generate tide heights between August 14 and September 13 (Figure 6). The generated tidal record was concatenated with the existing data to prepare the downstream head elevations for July 1 through September 30 (Figure 7). Ten feet were subtracted from the data in order to use the NGVD Datum, and the values were converted to meters to be used in the downstream head elevation file. The frequency of update was 15 minutes.

Table 3
Harmonic Analysis By Program Harmony

Tidal Constituent	Period (Hours)	Amplitude (Feet)	Phase (Hours)
M2	12.4206	1.9145355	-6.02333
S2	12.0160	0.2155625	-0.51766
N2	12.6584	0.4262123	-1.49841
K2	11.9672	0.3220898	3.41658
K1	23.9345	1.3110182	-4.57496
O1	25.8193	0.6358990	9.77714
P1	24.0659	0.3065934	1.00760
Q1	26.8684	0.0972851	-6.48325
L2	12.1916	0.2550533	-4.67744
J1	23.0985	0.0575548	-7.71121
M1	24.8412	0.1337846	10.28478
SO3	8.1924	0.0432117	1.48158
M4	6.2103	0.0349194	3.04906
M6	4.1402	0.0177467	-0.89193
M8	3.1052	0.0014191	1.28986
RMS = 0.437			

Downstream Head Boundary Constituent Concentrations

Downstream head boundary constituent concentrations (at the tidal boundary) were needed for TSS, salinity, DO, and BOD. The USGS provided continuous recordings of temperature and salinity at 15 minute intervals for the Carquinez Straight (Station ID 182130). Temperature and salinity probes were located 0.7 and 9.0 meters below Mean Lower Low Water (MLLW). The input file for downstream head boundary concentrations requires concentrations for all layers. Therefore, for both temperature and salinity, the surface measurement (0.7 meter) was assumed the surface layer value, the bottom measurement (9.0 meter) was assumed the bottom layer value, and intermediate layer values were linearly interpolated. The frequency of update was 15 minutes.

Based on measured TSS observations on August 10, 1994, and September 6, 1994, at RM 0, surface TSS was specified as 60 g m^{-3}, and the bottom TSS was specified as 120 g m^{-3}. Intermediate layer values were linearly interpolated. Specified TSS was constant over time.

Based on measured DO values at RM 0, dissolved oxygen was specified as 5.2 g m^{-3} from the surface through the bottom layer. BOD was specified as 1.0 g m^{-3} throughout the water column. Specified DO and BOD at the tidal boundary were constant over time.

Meteorological Data

Meteorological data used for the study were from Concord/Buchanan (STN ID 724936), acquired through the U.S. Air Force Environmental Technical Applications Center. The meteorological data required by CE-QUAL-W2 includes air temperature, dew point temperature, wind speed, wind direction, and cloud cover. The Napa Airport meteorological data record was inadequate. The Napa Airport meteorological data for 1994 consisted of 636 data records, but only two records contained temperature. It is not possible to use wind speed, wind direction, and cloud cover to calculate the missing temperatures. The next closest stations were Concord/Buchanan and Travis Air Force Base/Fairfield. Both of these stations had complete meteorological records for all required variables, and both were evaluated for computing water temperatures in the Napa River. The Concord/Buchanan data provided more accurate water temperature simulations.

Salt Evaporator Leachate

Both measured conductivity and initial simulations of salinity indicated that a source of conductivity/salinity occurred between RM 6 to RM 18.

Measured water quality longitudinal profiles conducted August 10 and September 6, 1994, revealed that conductivity increased between RM 6 and RM 18. CE-QUAL-W2 used salinity rather than conductivity. Conductivity was converted to salinity. Conversion formulae described in APHA(1992) were used to convert from conductivity to salinity. Measured temperatures were used in the conversion formulae. To compute a ratio between measured conductivity and sea water conductivity, a value of conductivity of seawater at 15 ° C and 35 ppt of 42.3975 mmhos was extracted from Duxbury (1971).

The measured salinity was greater than either inflow or downstream head concentrations; a source of salinity existed along the lower reaches of the Napa River. Examination of the Cuttings Wharf Quadrangle revealed an abandoned salt evaporator at RM 10 opposite Edgerley Island. It is believed that the salt evaporator leaches salinity into the Napa River.

To simulate leachate entering the river, a tributary was specified flowing into the Napa River at RM 9.4. The tributary flow was set to 0.125 $m^3 s^{-1}$, and the salinity concentration was set to 300 ppt. The solubility of NaCl in water at 25 °C is 361 ppt. The addition of a tributary source of salinity enabled close approximation to measured values. The flow value of 0.125 $m^3 s^{-1}$ was determined through calibration.

Hydrodynamic and Kinetic Coefficients

CE-QUAL-W2 requires specification of hydrodynamic and kinetic coefficients. Table 4 presents important coefficients that differed from default values that were supplied with the code. The coefficient values selected were within ranges of reported values (Cole and Buchak, 1995).

The source/sinks of DO in the Napa River application were surface reaeration, BOD decay, and sediment oxygen demand (SOD). It was anticipated that a major sink for DO is algal respiration; however, algae were not simulated due to a lack of sufficient algal and nutrient data. Measured SOD values for the Napa River were not available; however, SOD was used as a calibration parameter to match measured DO. Literature values for SOD vary from 0.1 to 5.8 g O_2 m^2 day^{-1} (Cole and Buchak 1995). The SOD values used are listed in Table 5. The larger value used between RM 10 and RM 18 was used to account for the abandoned sewage disposal pit.

Initial Conditions

Initial conditions were required for temperature, TSS, salinity, DO, and BOD. The water quality survey on August 10, 1994, provided measurements of temperature at 1 foot depth, DO at 10 foot depth, and TSS and conductivity 3 feet below the surface and 3 feet above the bottom that were used for initial conditions. Initial conditions for ultimate BOD were globally set equal to 2.6 g m^{-3}. For temperature and DO, measured values were interpolated

longitudinally and assumed equal throughout depth. TSS and salinity measurements taken 3 feet below the surface were assumed top layer values, and measurements taken 3 feet above the bottom were assumed bottom layer values. The values were first longitudinally interpolated and then vertically interpolated to assign values to all cells.

Table 4
Important Hydrodynamic and Kinetic Coefficients

Coefficient	Description	Value
CHEZY	Chezy coefficient, $m^{0.5}$ sec^{-1}	40.0
EXH2O	Light Extinction for water, m^{-1}	0.7
EXSS	Extinction due to inorganic suspended solids, m^3 $m^{-1}g^{-1}$	0.0
EXOM	Extinction due to organic suspended solids, $m^3m^{-1}g^{-1}$	0.0
BETA	Fraction of incident solar radiation absorbed at the water surface	0.5
SSETL	Suspended solids settling rate, m day^{-1}	0.5
KBOD	BOD decay rate @ 20 °C, day^{-1}	0.25
TBOD	Temperature correction coefficient for BOD decay	1.0147
RBOD	Ratio ultimate BOD to BOD5	1.85

Table 5
Sediment Oxygen Demand (SOD) Values Used

Location	Value, g O_2 m^2 day^{-1}
RM 0 through RM 10	1.0
RM 10 through RM 18	4.0
RM 18 through RM 22	1.5

3 Results

Calibration

Snapshots of simulated constituent concentrations were made corresponding to times of sample collection during the water quality surveys conducted August 10 (Julian Day 222), and September 6 (Julian Day 249), 1994. The water quality samples were taken at high water slack which represented a 2 hour 32 minute interval between RM 0 and RM 20. Simulation snapshots were taken at 1-hour intervals during Julian dates 222 and 249. Close examination of simulated water level between 1:30 pm and 4:15 pm on September 6, 1994, revealed a falling tide at sampling times which does not correspond to the observed high-water slack. Since the tidal record was generated for this interval, it is assumed that phase estimates were in error. The mid-time of water quality sampling during September 6 was 2:52 pm which should correspond to high-water slack at RM 10. Using the generated tidal record, high-water slack occurred at RM 10 at 12:30 pm, a phase error of two hours. A phase error of two hours in predicted tidal record for Carquinez Strait has no impact on comparison between existing and project conditions.

Temperature

Figures 8 and 9 display simulated and measured surface temperature for Julian days 222 (August 10) and 249 (September 6), respectively. The temperature calibration indicates disparity between measured and simulated temperature. The reason for simulated and measured data disagreement was the meteorological data used. The meteorological data collected at the Napa County Airport were too sparse to use, thus meteorological data collected at Concord/Buchanan were used. However, the inability to accurately simulate temperature indicates that the meteorological data from Concord/Buchanan were not representative of conditions at Napa. The Concord/Buchanan station was located 21 miles from the Napa Country Airport across Suisun Bay.

A second station with adequate meteorological data was Travis AFB/Fairfield (STN ID 745160) which was 19 miles away. Simulated temperatures were much lower using Travis AFB/Fairfield meteorological data (Figures 10 and 11). A comparison of meteorological data during the

simulation period indicates that the major difference was greater wind speed at Travis than at Concord/Buchanan. Wind affects water temperature by increasing evaporative cooling. The Concord/Buchanan-Travis/Fairfield comparison indicates that meteorological data from the Napa River site are required for accurate temperature simulation.

Temperature is important because it affects the density of water and thus the hydrodynamics and the kinetic reaction rates. However, the simulated temperatures are considered close enough to observed values to compare the effects of the flood control project on water quality.

Total Suspended Solids

Figures 12 through 15 display simulated and measured TSS for Julian Days 222 and 249 for both the surface and bottom layers. TSS was simulated relatively well.

Salinity

Simulated and measured surface and bottom salinity is displayed in Figures 16 through 19. The spikes simulated in bottom salinity are a result of deeper, more quiescent cells in the computation grid. The computational grid was prepared using cross-section data, and adjacent cross-sections frequently had different bottom depths. There was no attempt to longitudinally smooth cross-section morphology. The quiescent cells represent segments where bottom depths were greater than adjacent segments. The salinity results are quite good considering that no hydrodynamic data, such as water surface elevation or velocity measurements, were available for model comparison and adjustment.

Dissolved Oxygen

Examination of Figures 20 and 21 indicates that simulated DO patterns at 3.0 m depth approximate measured values. Simulated and measured DO values in the project reach RM 15.6 through RM 19.1 differ by less that 1 g m^{-3}. The times selected for the calibration comparisons (Julian Day 222.681 and 249.240) were selected to correspond to the mid-time of the sampling surveys. Some calibration comparisons during August 10 (Julian Day 222.241) and September 6 (Julian Day 249.681) revealed that simulated DO more closely approximated measured values (Figures 22 and 23). The dissolved oxygen calibration is remarkably good.

Comparison

Comparisons consisted of overlaying simulation results for existing and project conditions to correspond with the snapshots used during calibration. The only difference between existing and project conditions was the

bathymetry in the project reaches. Differences in bathymetry was in cross-section widths.

Temperature

Figures 24 and 25 display surface temperature for the existing and project conditions. Existing and project temperatures are equivalent except for a noticeable difference of around 1 °C in the project reach.

Total Suspended Solids

Figures 26 through 29 indicate essentially no difference in simulated surface and bottom TSS for existing and project conditions.

Salinity

A comparison of simulated surface and bottom salinity between existing and project conditions indicates no differences (Figures 30 through 33).

Dissolved Oxygen

A comparison of dissolved oxygen concentrations at 3 m depth for existing and project conditions on August 10 and September 6 reveals that project conditions result in decreased DO in the project reaches of the Napa River (Figures 34 and 35). The maximum decrease is less that 1 g m^{-3}. The hypothesized explanation for the observed DO decrease following channel widening is increased residence time (due to lower velocities) in the project reaches. Longer residence time increased the exertion of SOD on the DO concentration of the overlying water column.

A simulation was conducted recording cell DO concentration each iteration between August 1 and September 30. Figure 36 displays a comparison of average DO by RM for both existing and project conditions at 3 m depth. Examination of Figure 36 indicates that deviation between existing and project conditions occurs in the project reach. The average maximum decrease in DO following project implementation is less that 0.5 g m^{-3}.

4 Summary and Conclusions

A two-dimensional (laterally-averaged) numerical water quality model, CE-QUAL-W2, was applied to the Napa River, and simulation results from existing and project conditions were compared. The project is designed for the 100-year flood. The project includes a channel modification of excavation and widening of the channel above mean-tide level between Third Street downstream to Kennedy Park and the creation of a floodway through the city of Napa. Temperature, TSS, salinity, and DO were compared between existing and project conditions.

The study consisted of two steps: (1) calibration to existing conditions and (2) comparison of existing and project conditions. Constituents simulated include temperature, TSS, salinity, DO, and ultimate BOD.

Temperature calibration indicated that local meteorological data are required for accurate temperature simulation. Temperature calibration was adequate for existing and project comparison, but precise temperature simulation requires frequent meteorological data collected near the site. TSS and salinity were accurately simulated. Simulated DO patterns approximated measured values, and simulated values in the project area differed from measured values less than 1.0 g m^{-3}.

Temperature comparison between existing and project conditions indicated equivalent temperatures except in the project area. Differences were less that 1 °C. The differences were due to increased surface area in the project conditions which accelerates heat exchange between the water column and atmosphere. Comparison of TSS and salinity between existing and project conditions indicated little or no difference.

A comparison of dissolved oxygen concentrations between existing and project conditions indicated that project conditions resulted in decreased DO in the project area. The decrease in DO was less than 1 g m^{-3}. The simulated decrease in DO with project conditions was due to increased residence time that resulted in increased time that SOD could exert DO depletion in the water column. A comparison of the arithmetic average of DO for each iteration

between August 1 and September 30 indicated that deviation between existing and project conditions only occurred in the project reach. However, maximum decrease was less that 0.5 g m^{-3}.

Numerical water quality simulations indicated that the 100-year flood control project resulted in changes in water quality. The changes in water quality were minimal and no changes in project design are recommended to further minimize water quality changes.

References

APHA . 1992. *Standard Methods for the Examination of Water and Wastewater, 18th Edition*, American Public Health Association, Washington, DC.

Cole, T.M., and Buchack, E.M. 1995. "CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 2.0; Version 2; Users Manual", Instruction Report EL-95-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Duxbury, A.C. 1971. *The Earth and Its Oceans*, Addison-Wesley, Reading, MA.

Environmental Engineering Branch. 1995. "NAPA RIVER FLOOD CONTROL PROJECT: Water Quality Study," Report by: Environmental Engineering Branch, Sacramento District, U.S. Army Corps of Engineers, Sacramento, CA.

Schoellhamer D.H. 1997. D.H. Schoellhamer of the USGS provided the following data:

a. WY1996 Napa River discharge data (USGS Water-Data Report CA-96-2.

b. Oltman, unpublished data:

1. Stage data for 1994-1996 at the Wickland Oil Terminal
2. Salinity and temperature data for 1994-1996 at the Wickland Oil Terminal

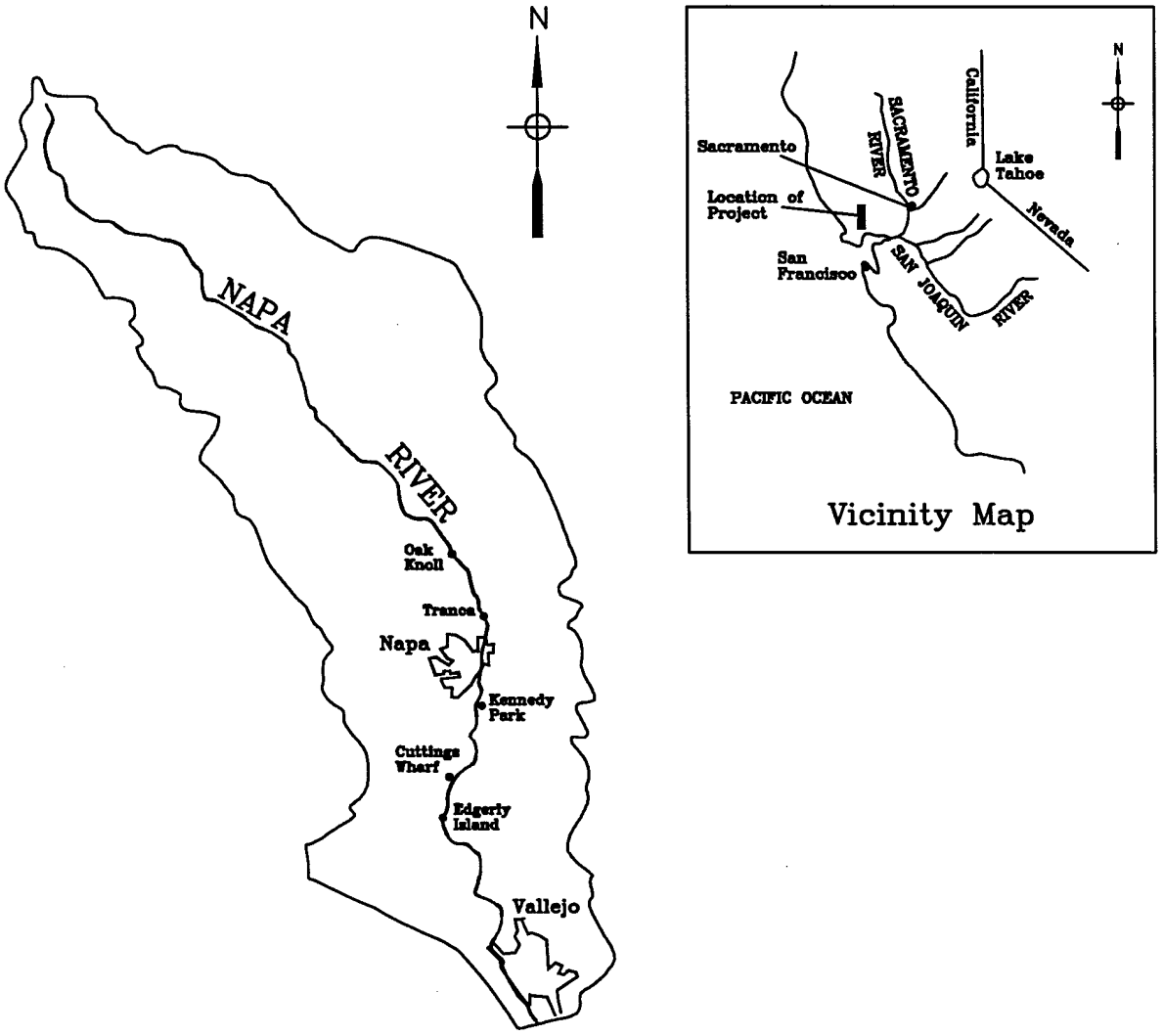


Figure 1. Napa River and Vicinity Map

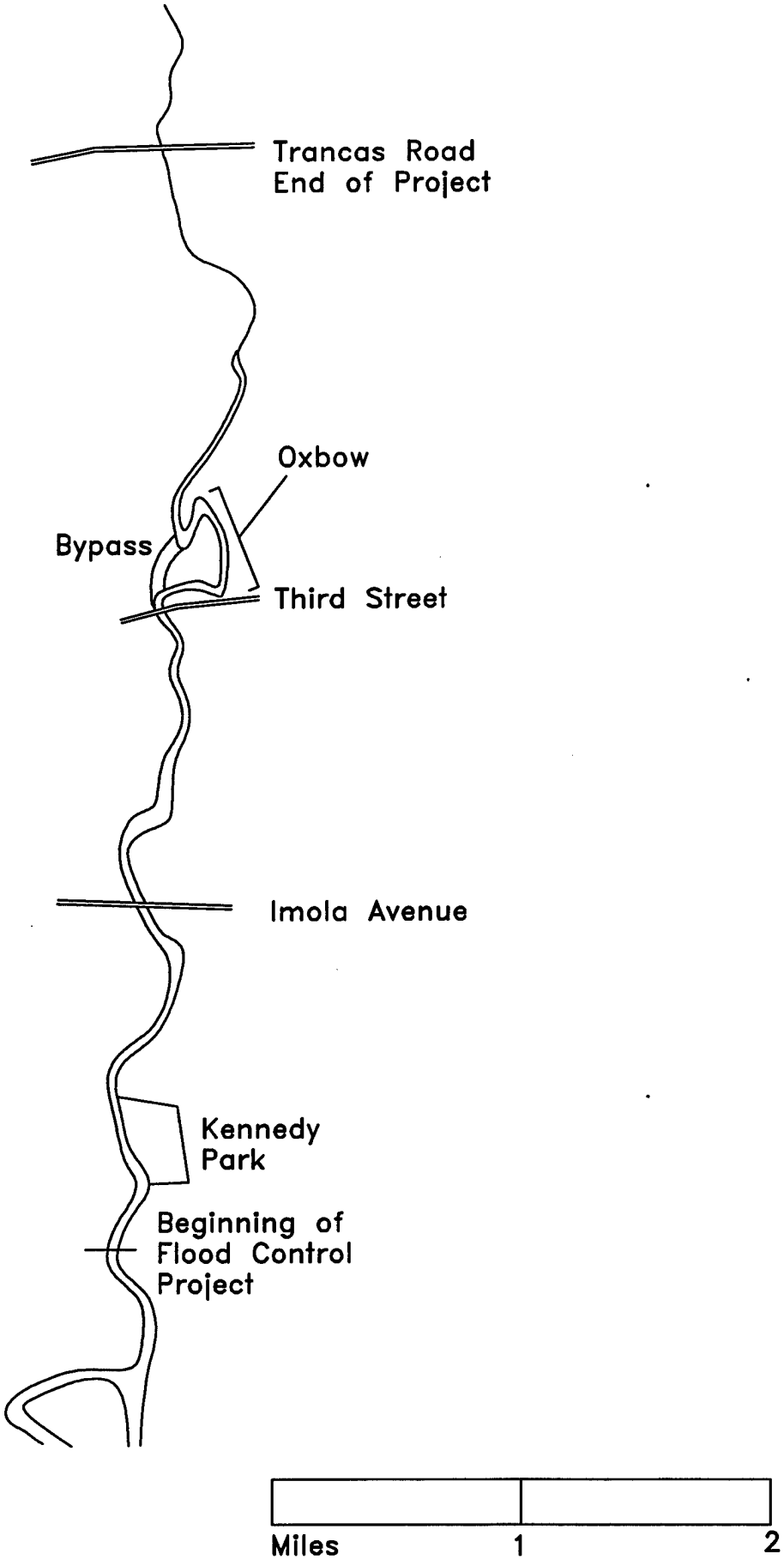


Figure 2. Site Map

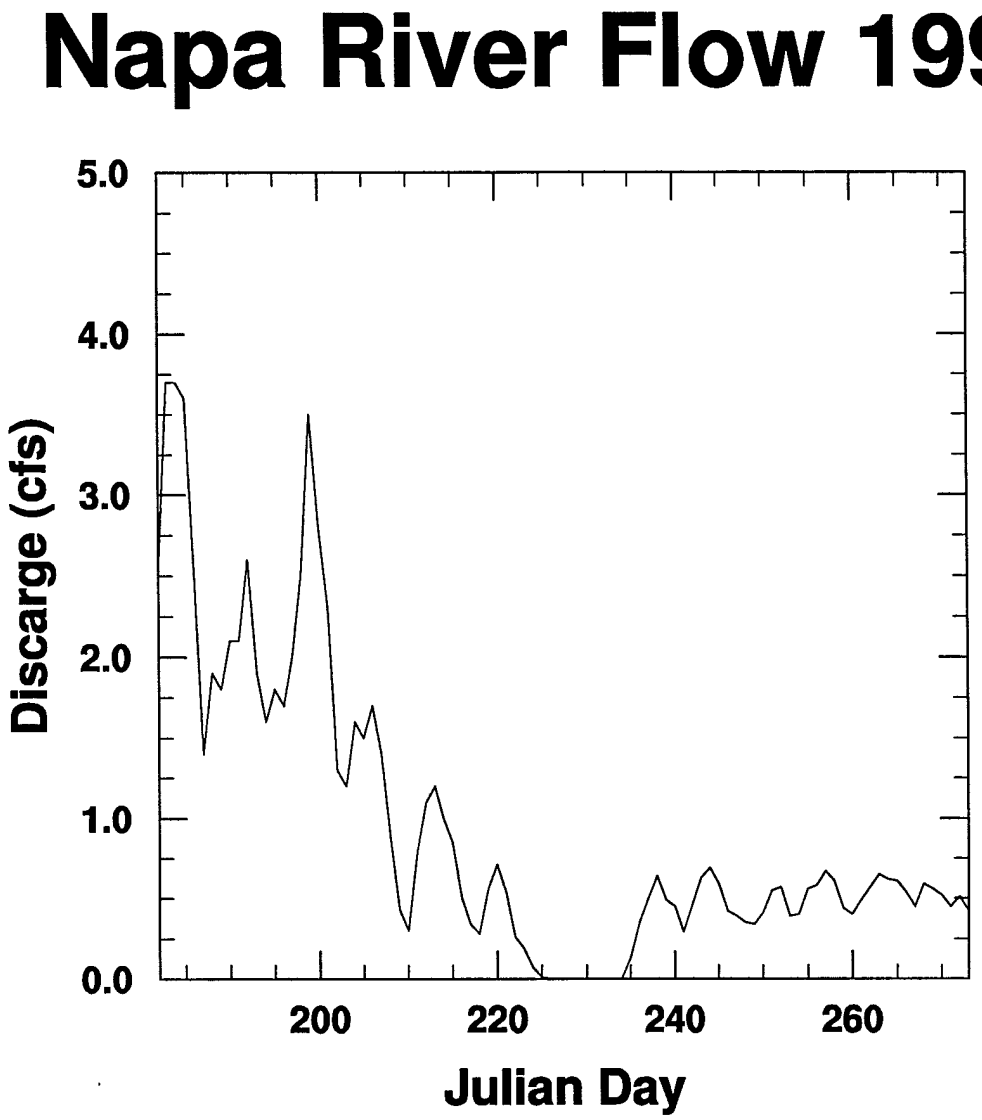


Figure 3. Napa River flow (Oak Knoll gage), July 1 - September 30, 1994

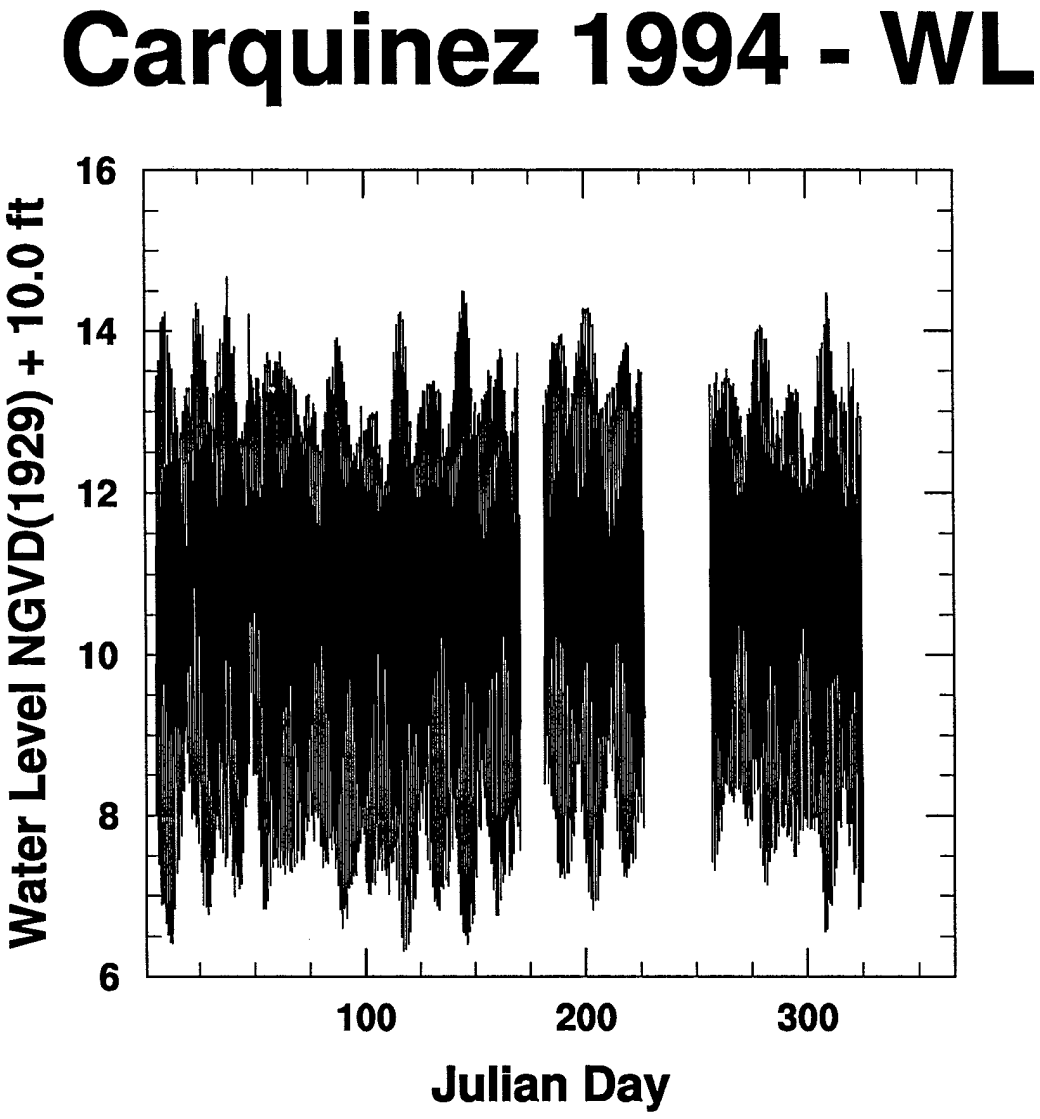


Figure 4. Carquinez tide gage data, 1994

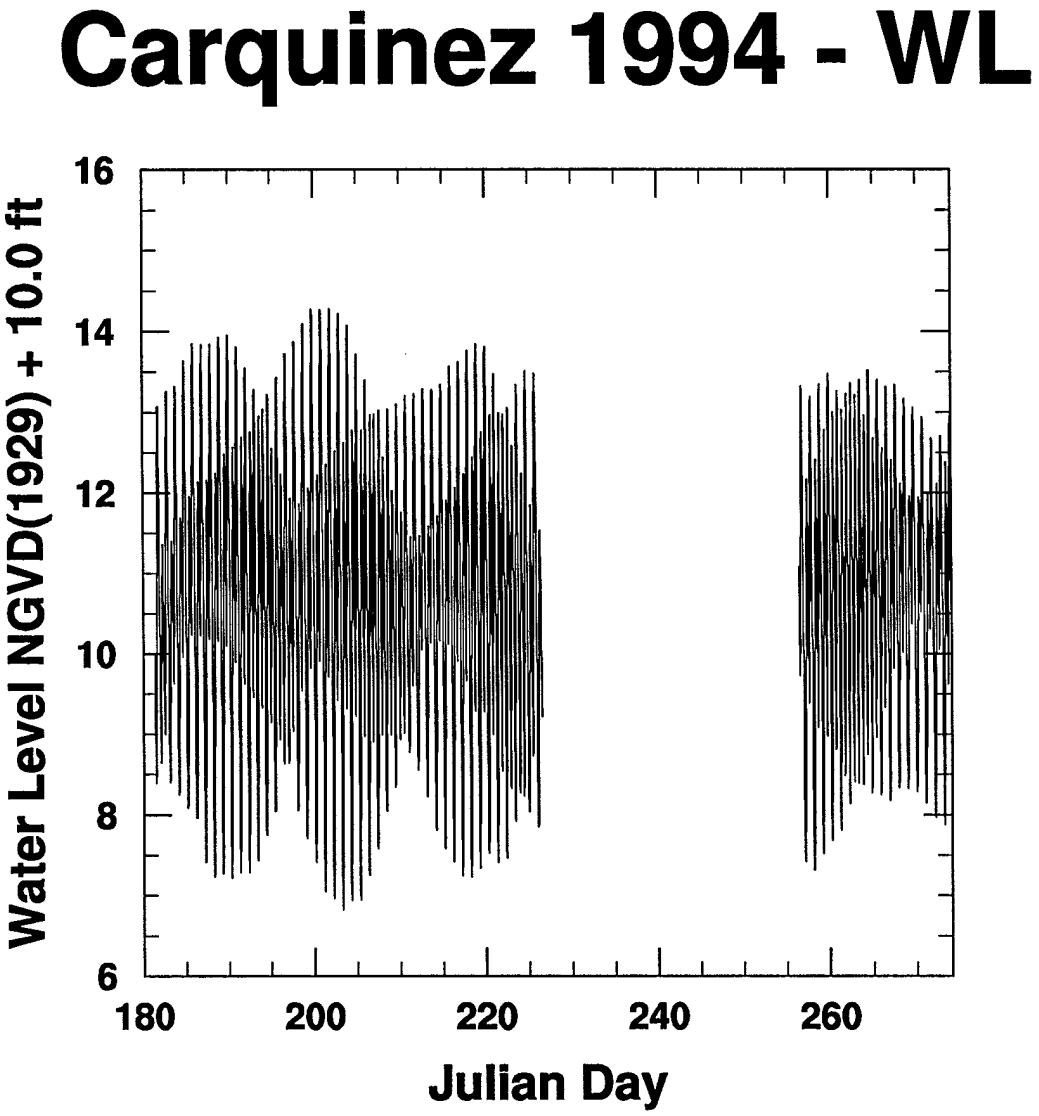


Figure 5. Carquinez tide data, July 1 - September 30, 1994

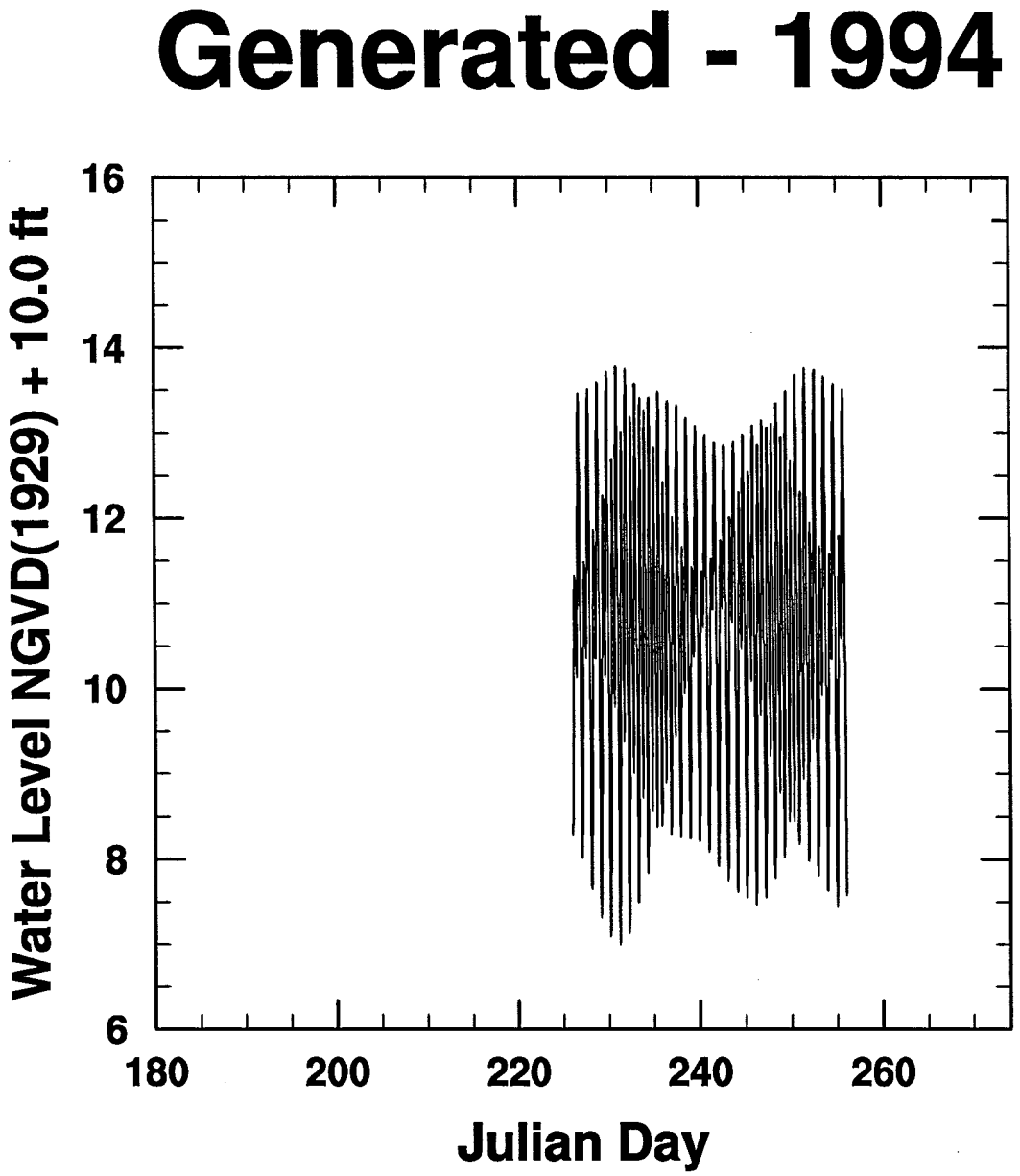


Figure 6. Generated Carquinez tide data, August 10 - September 30, 1994

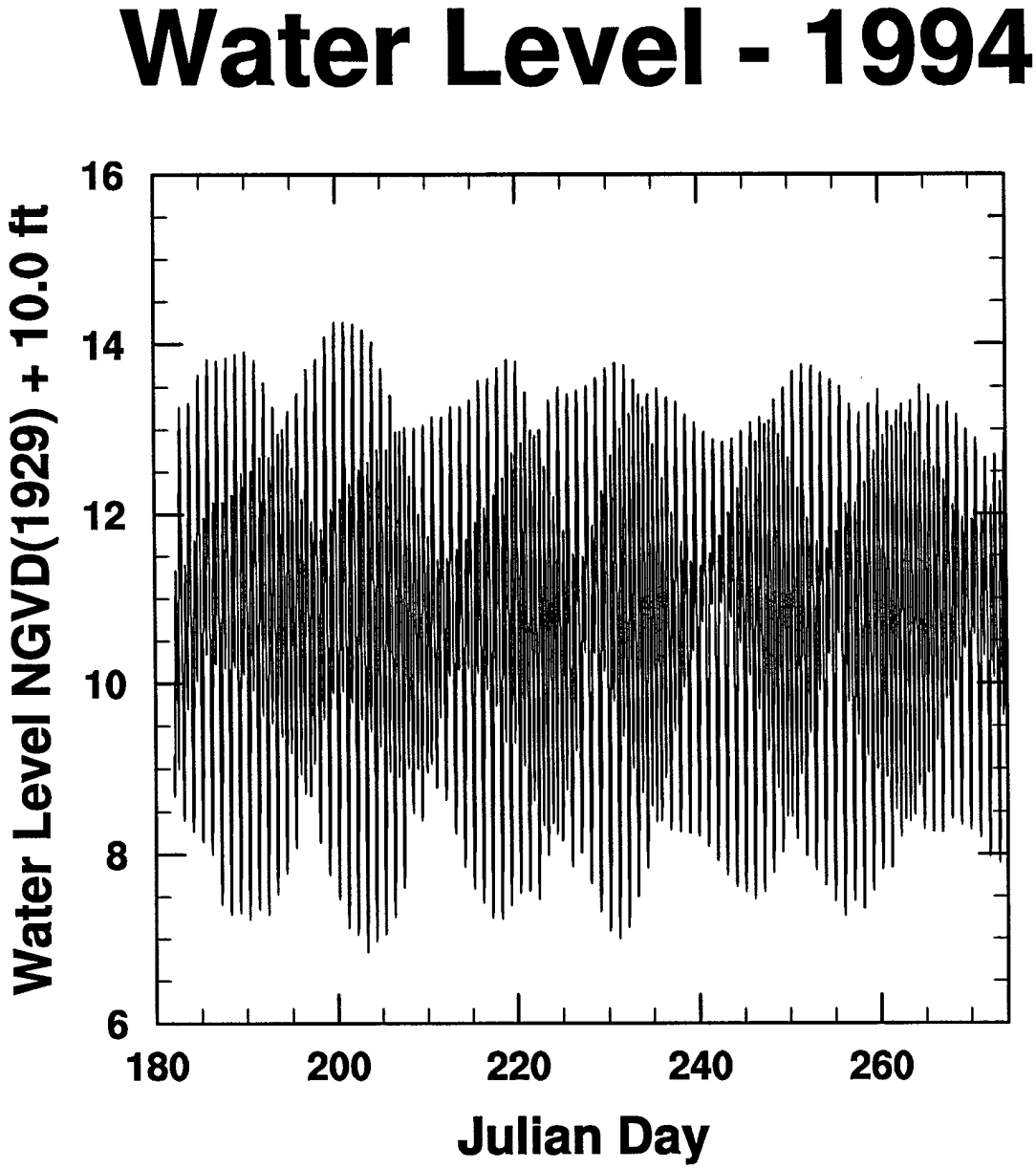


Figure 7. Existing plus generated tide data, July 1 - September 30, 1994

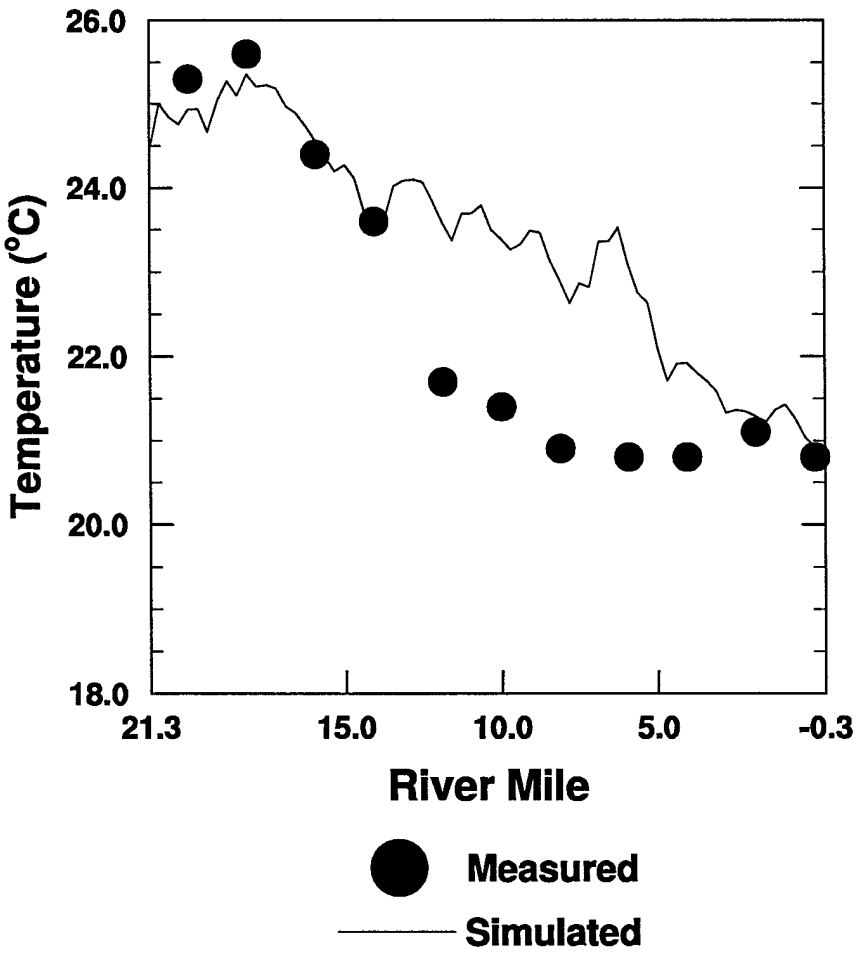


Figure 8. Temperature calibration, August 10, 1994

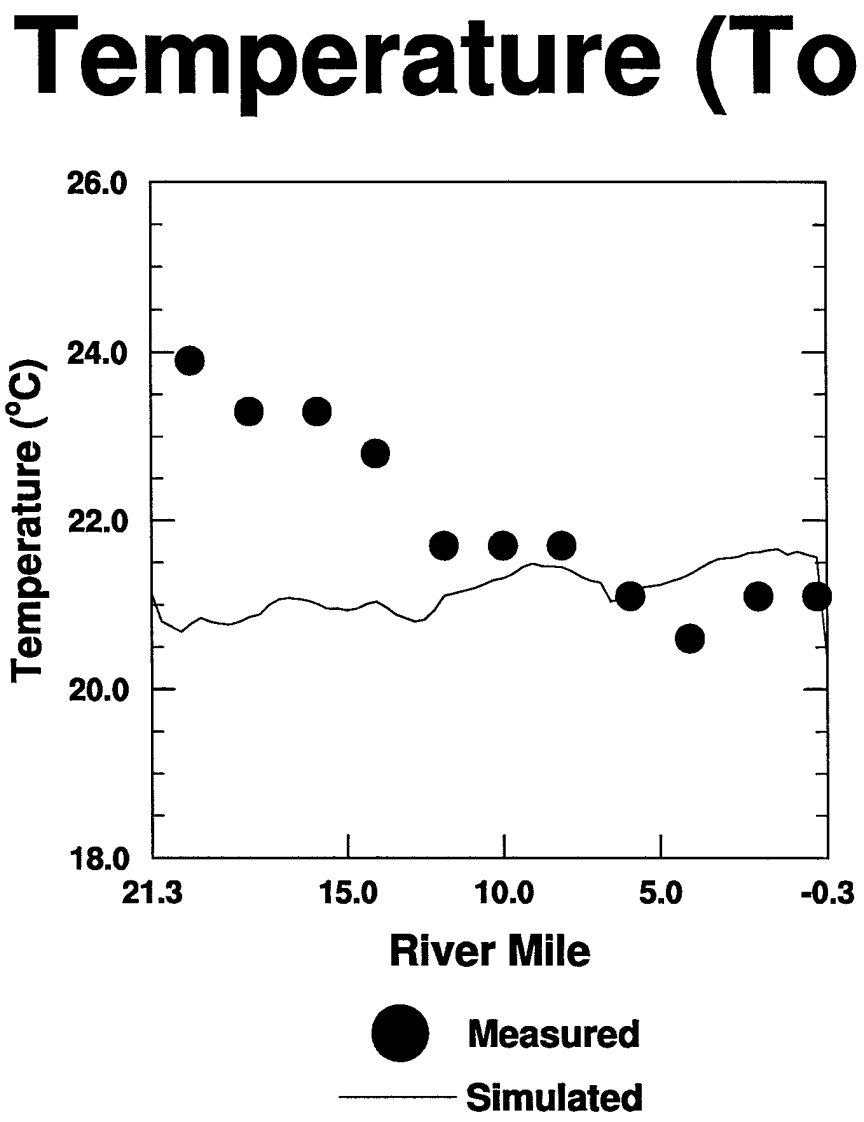
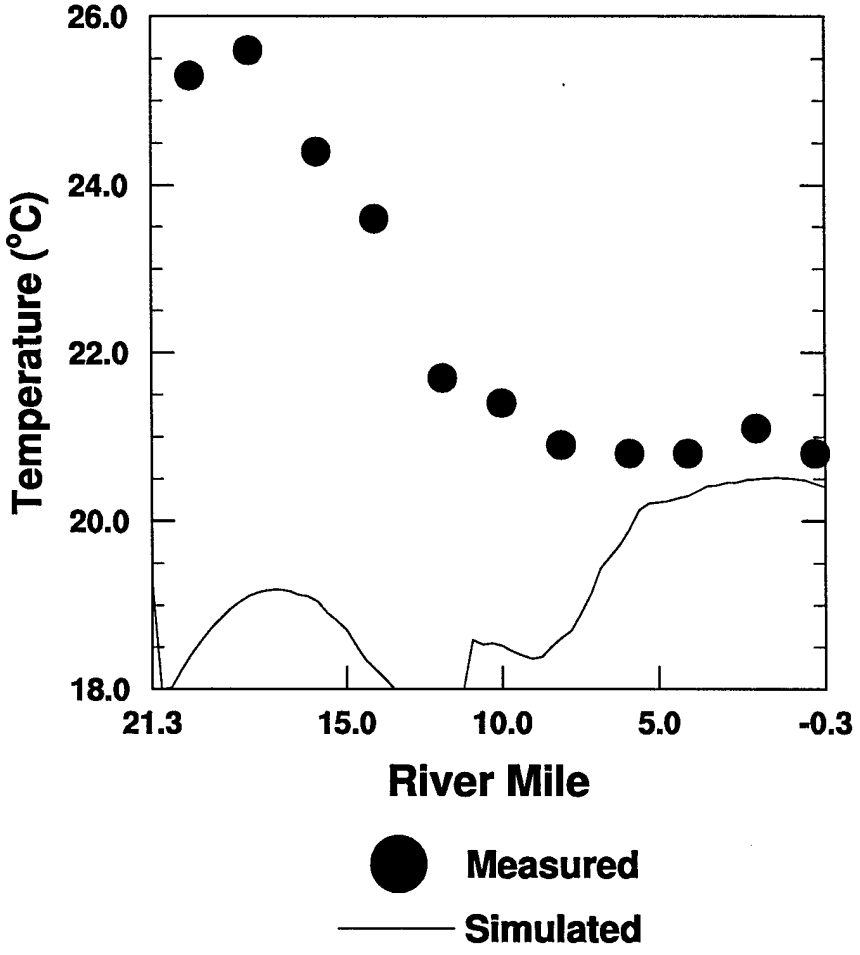


Figure 9. Temperature calibration, September 6, 1994

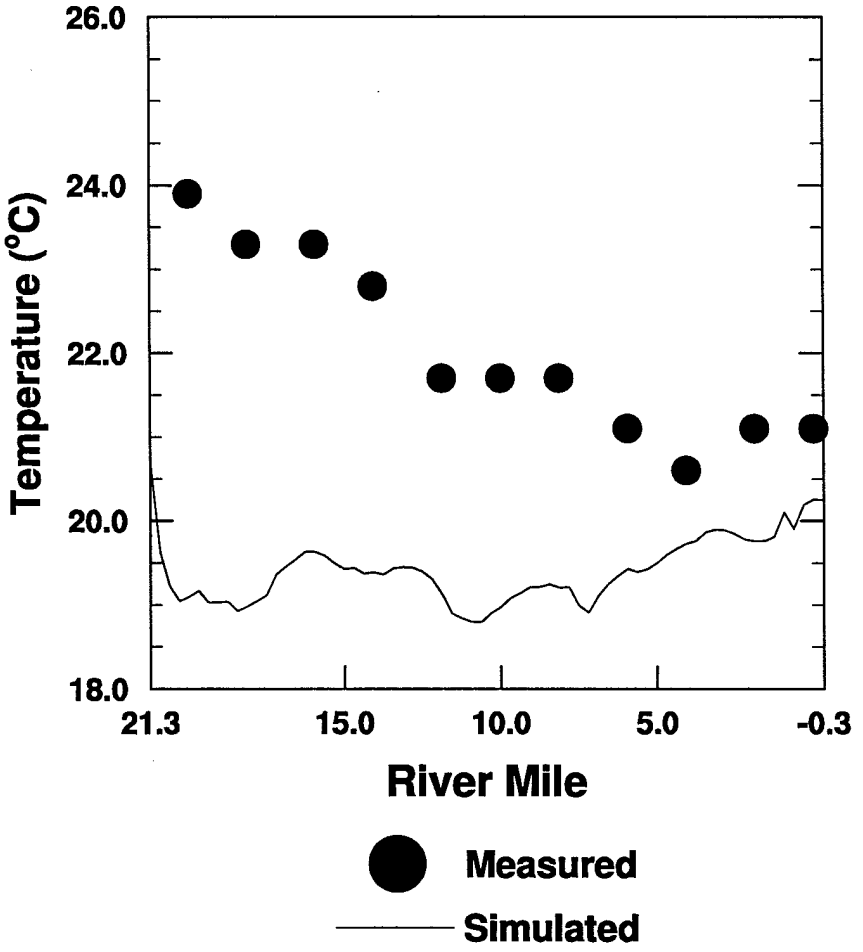
Temperature - Travis



Day 222.681

Figure 10. Temperature calabration using Travis AFB meteorological data, August 10, 1994

Temperature - Travis



Day 249.242

Figure 11. Temperature calabration using Travis AFB meteorological data, September 6, 1994

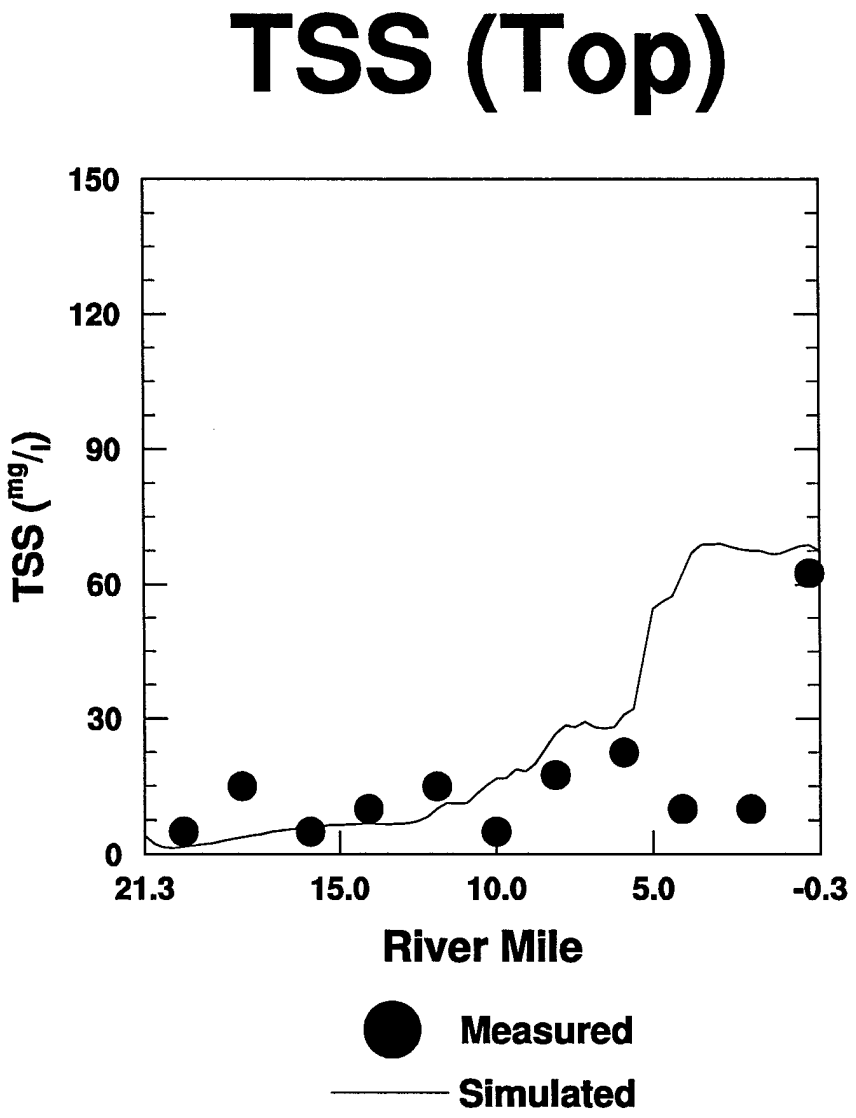


Figure 12. Surface TSS caliboration, August 10, 1994

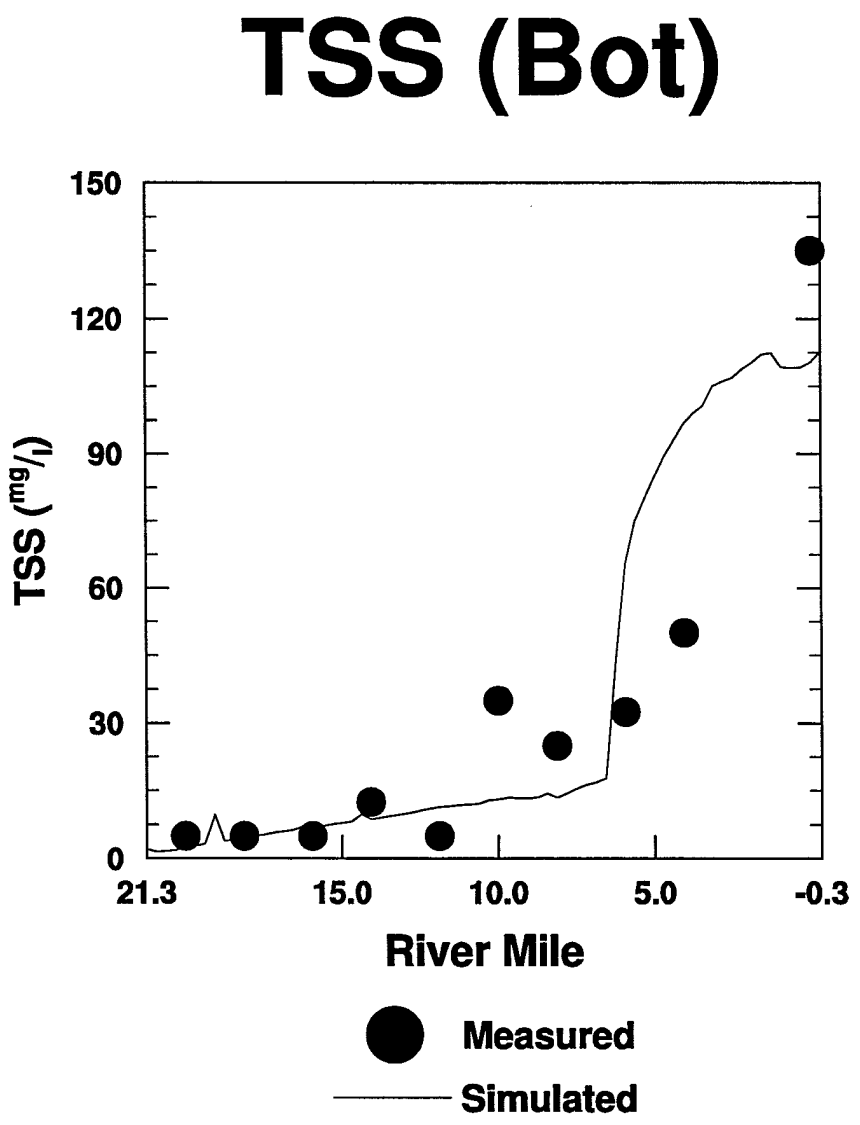


Figure 13. Bottom TSS calibration, August 10, 1994

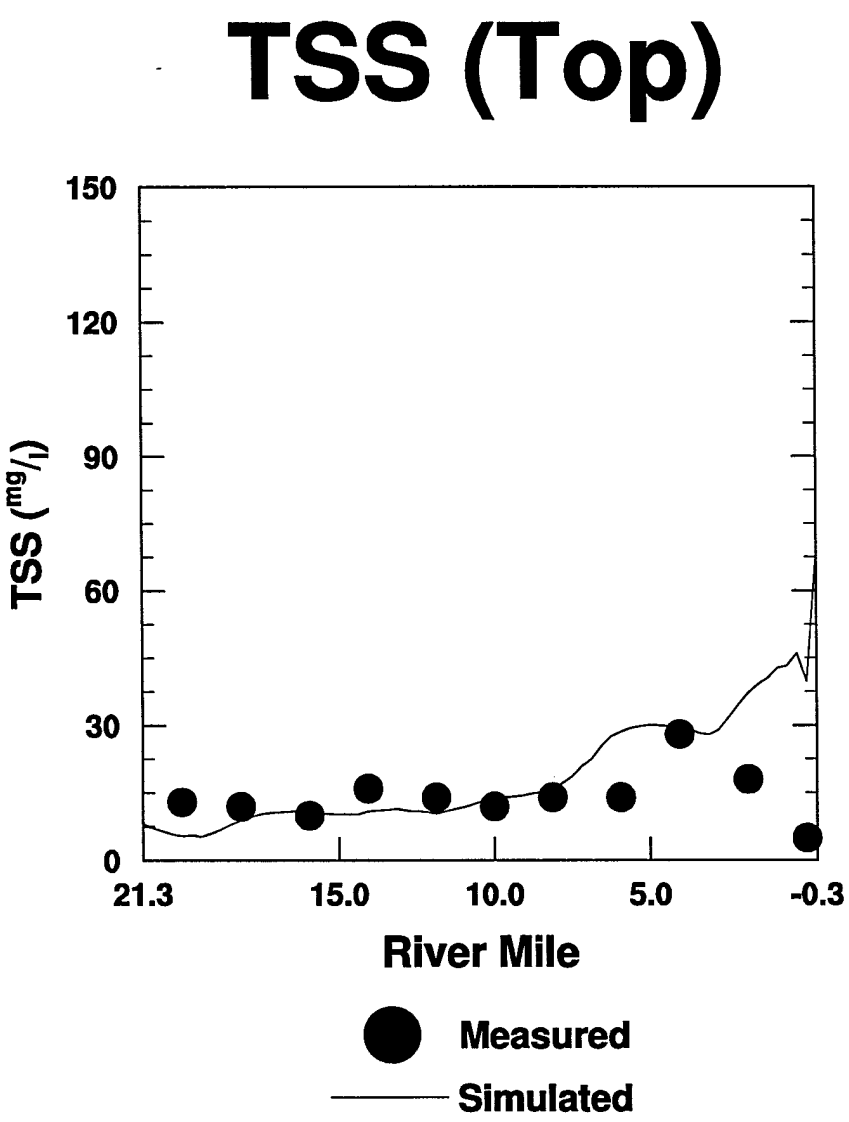


Figure 14. Surface TSS calibration, September 6, 1994

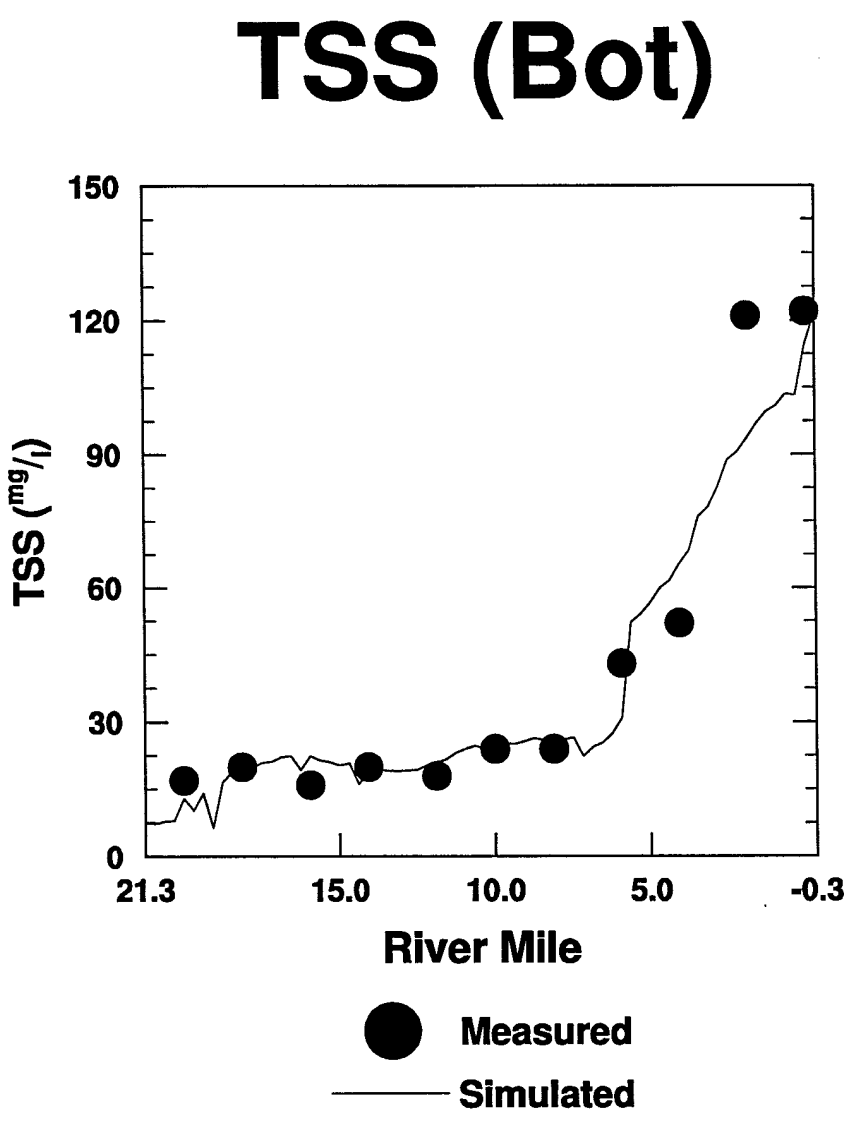


Figure 15. Bottom TSS calibration, September 6, 1994

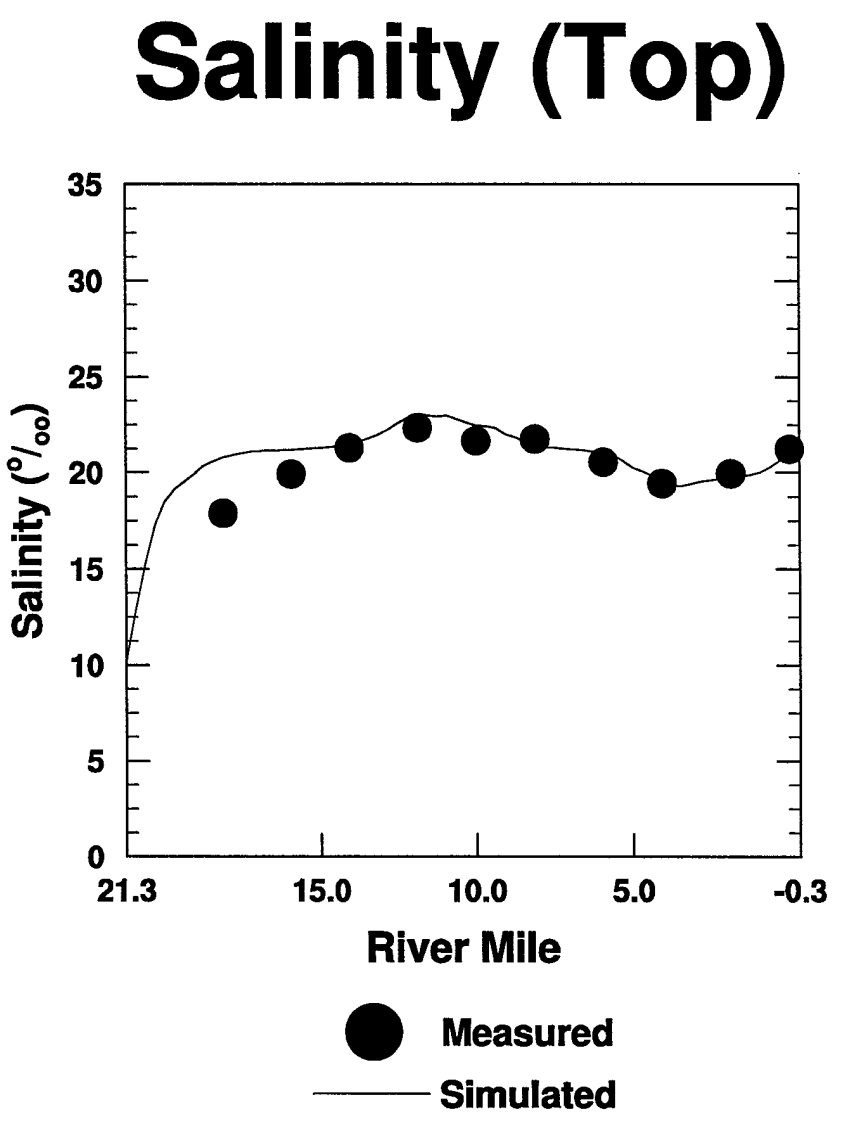


Figure 16. Surface salinity calibration, August 10, 1994

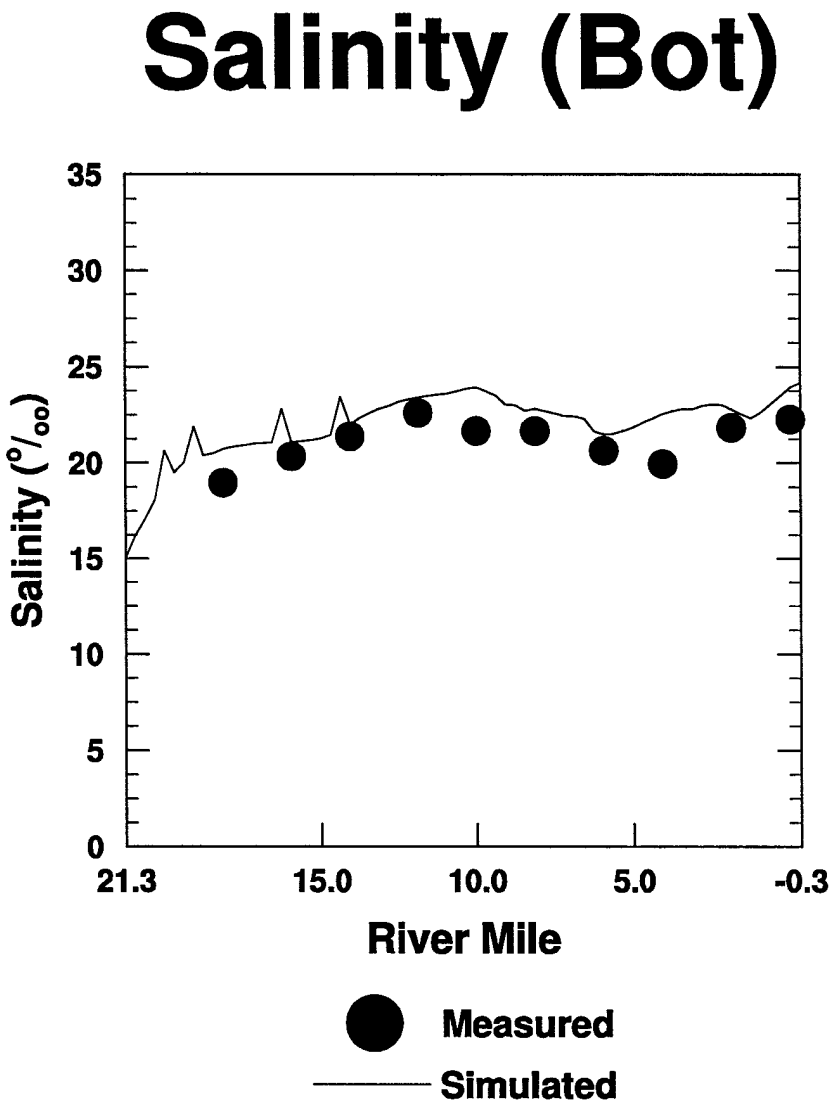
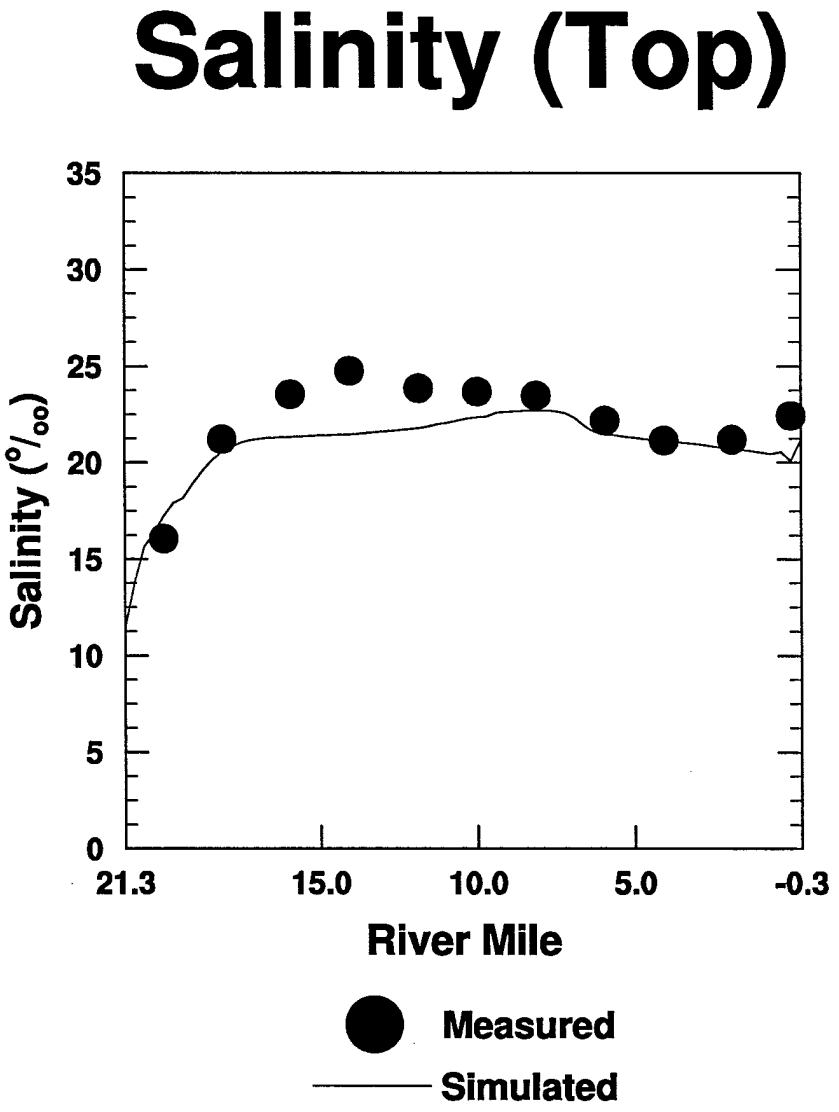


Figure 17. Bottom salinity calibration, August 10, 1994



Fibure 18. Surface salinity calibration, September 6, 1994

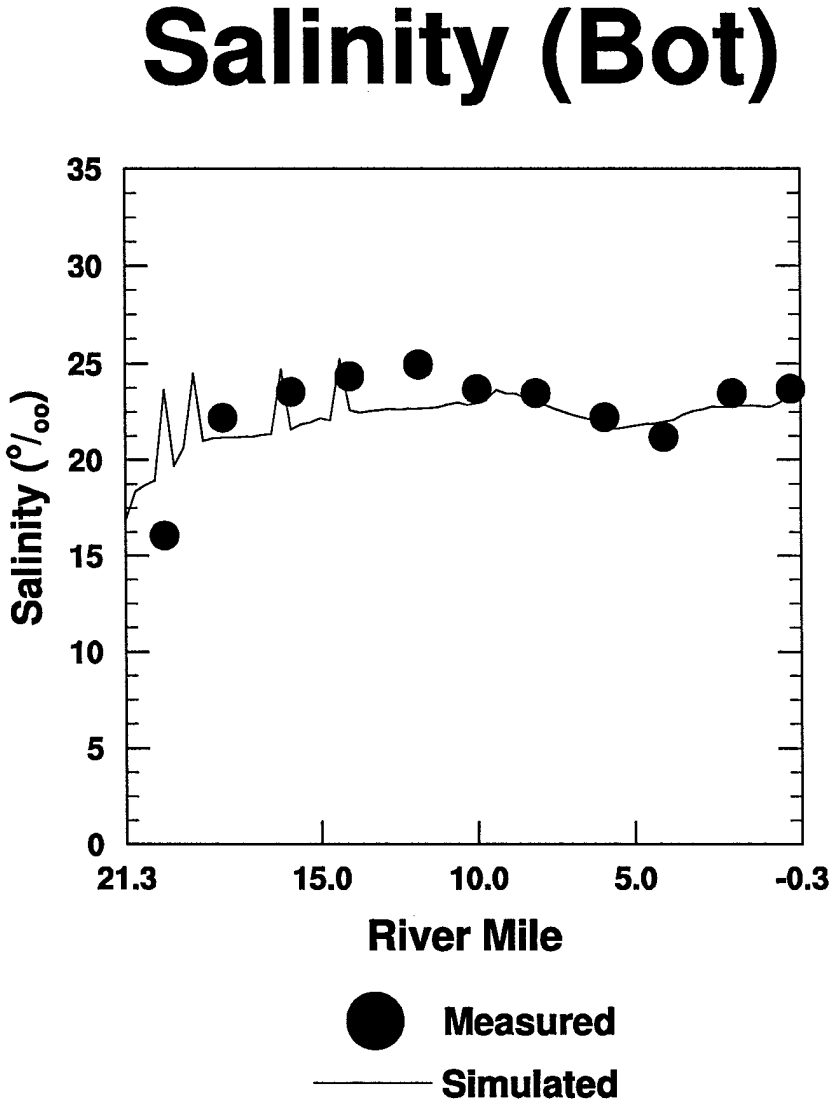
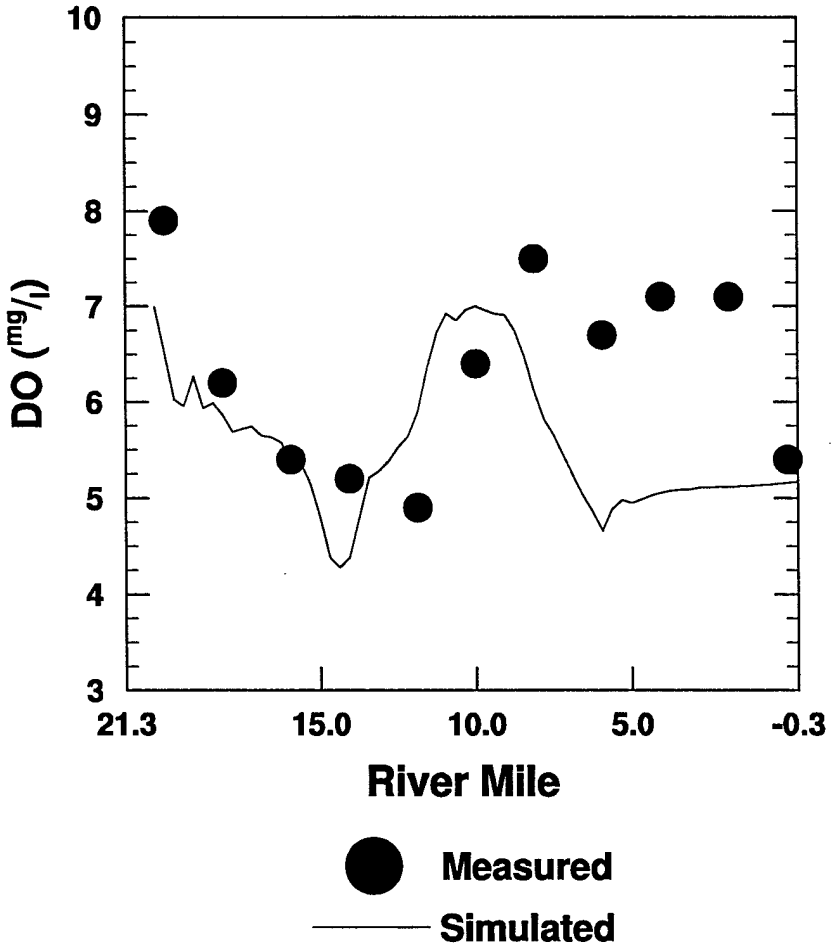


Figure 19. Bottom salinity calibration, September 6, 1994

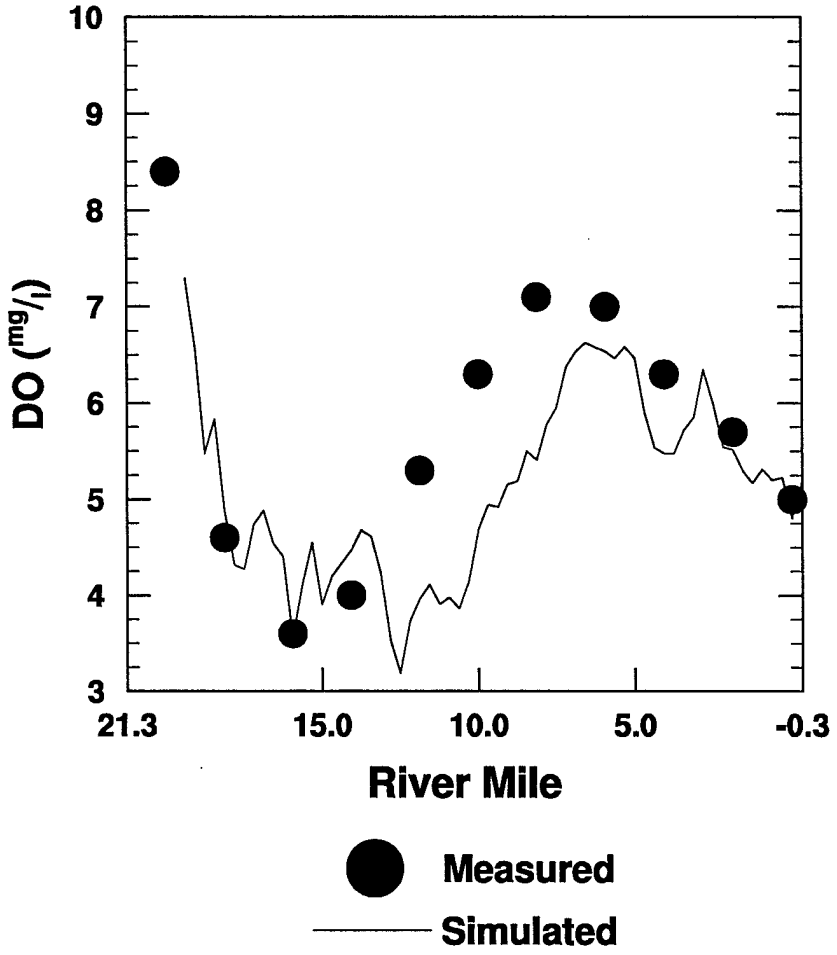
Dissolved Oxygen (3 m)



Day 222.681

Figure 20. DO calibration, August 10,1994

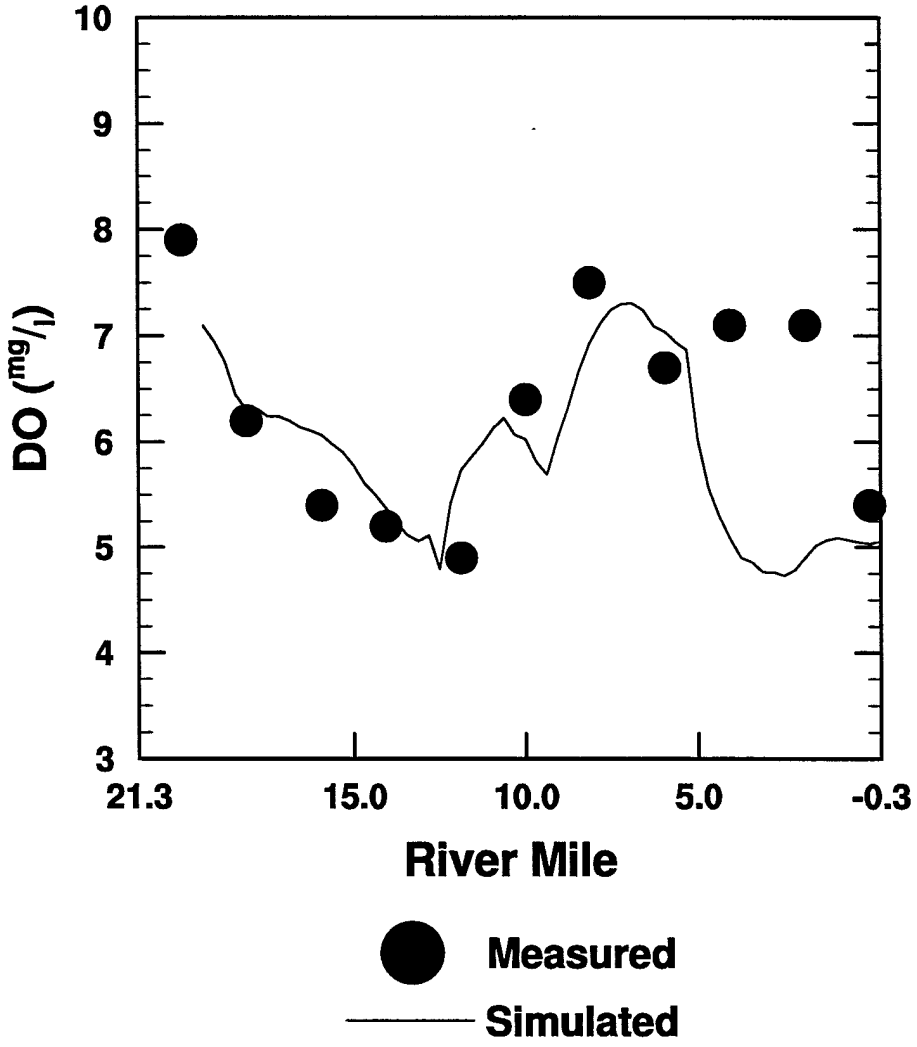
Dissolved Oxygen (3 m)



Day 249.240

Figure 21. DO calibration, September 6, 1994

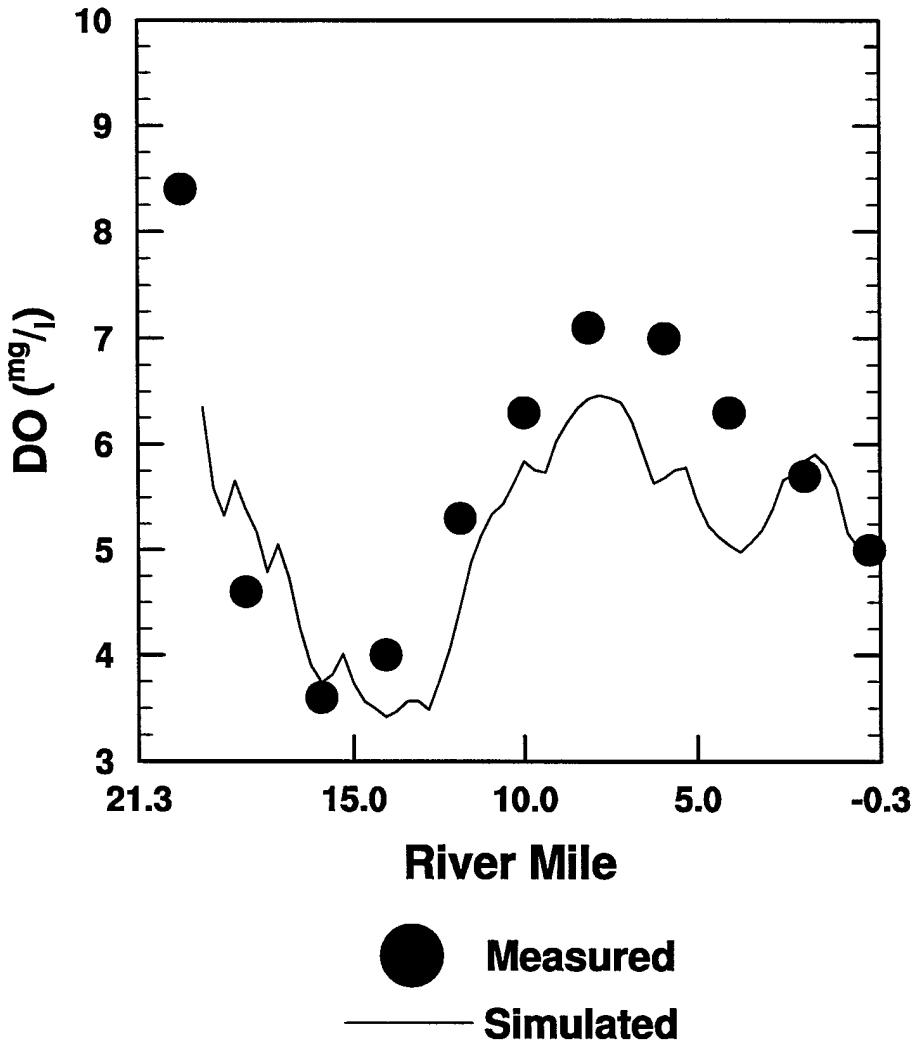
Dissolved Oxygen (3 m)



Day 222.241

Figure 22. DO calibration (alternate time), August 10, 1994

Dissolved Oxygen (3 m)



Day 249.681

Figure 23. DO calibration (alternate time),September 6, 1994

Temperature (Top)

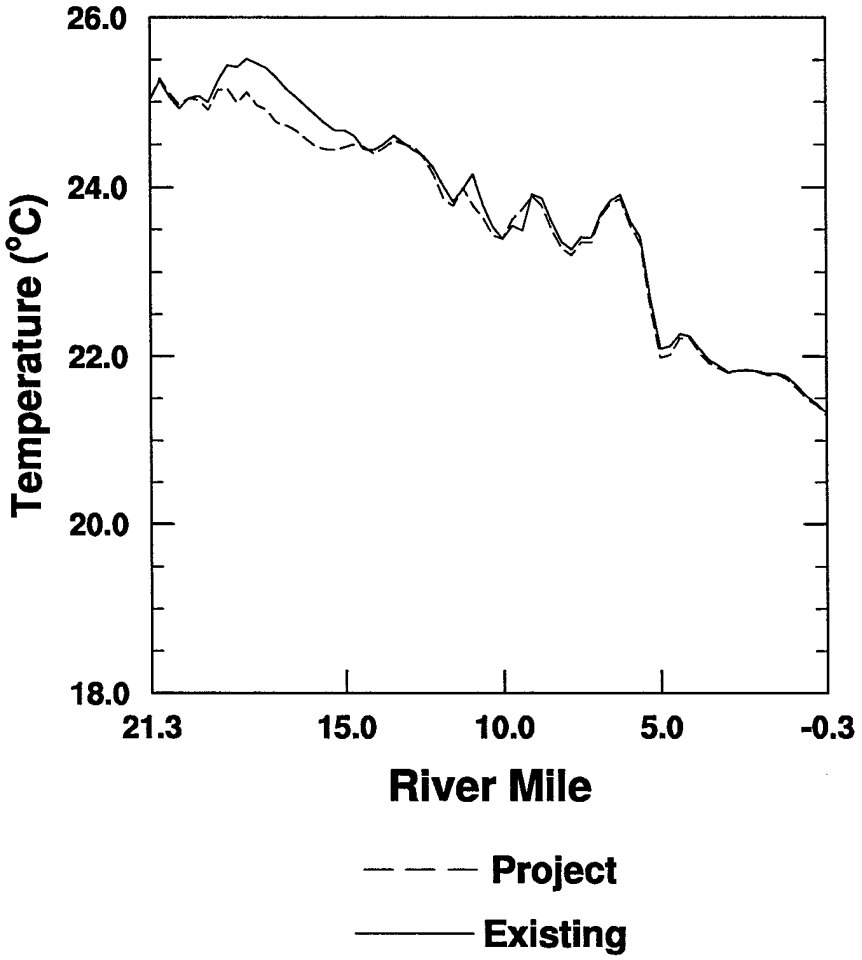


Figure 24. Temperature comparison, August 10, 1994

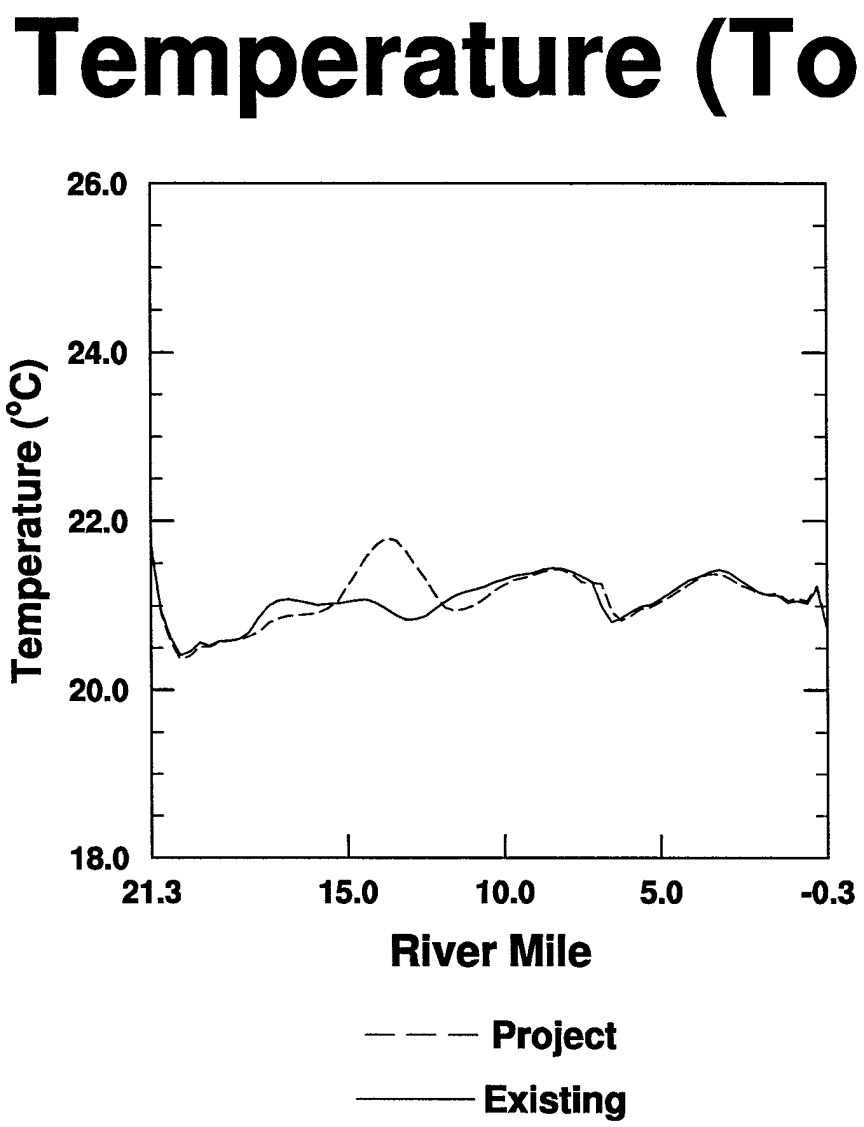


Figure 25. Temperature comparison, September 6, 1994

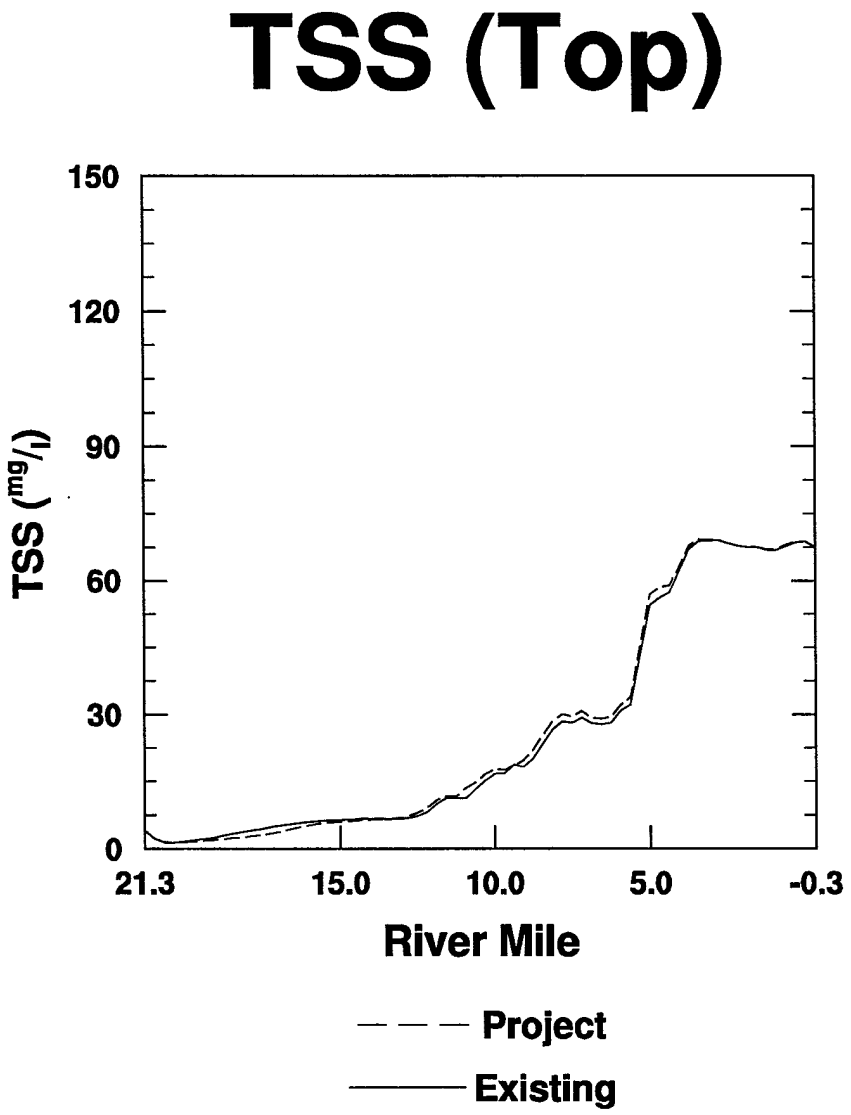


Figure 26. Surface TSS comparison, August 10, 1994

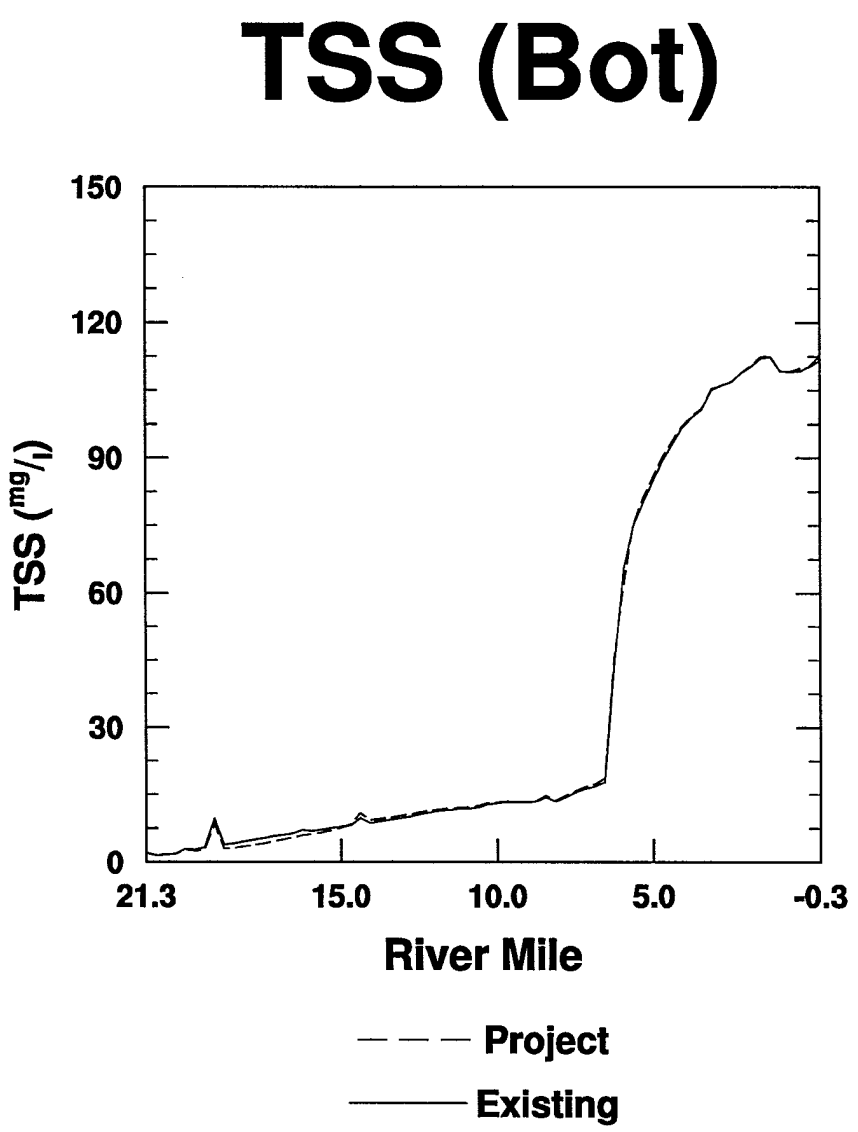


Figure 27. Bottom TSS comparison, August 10, 1994

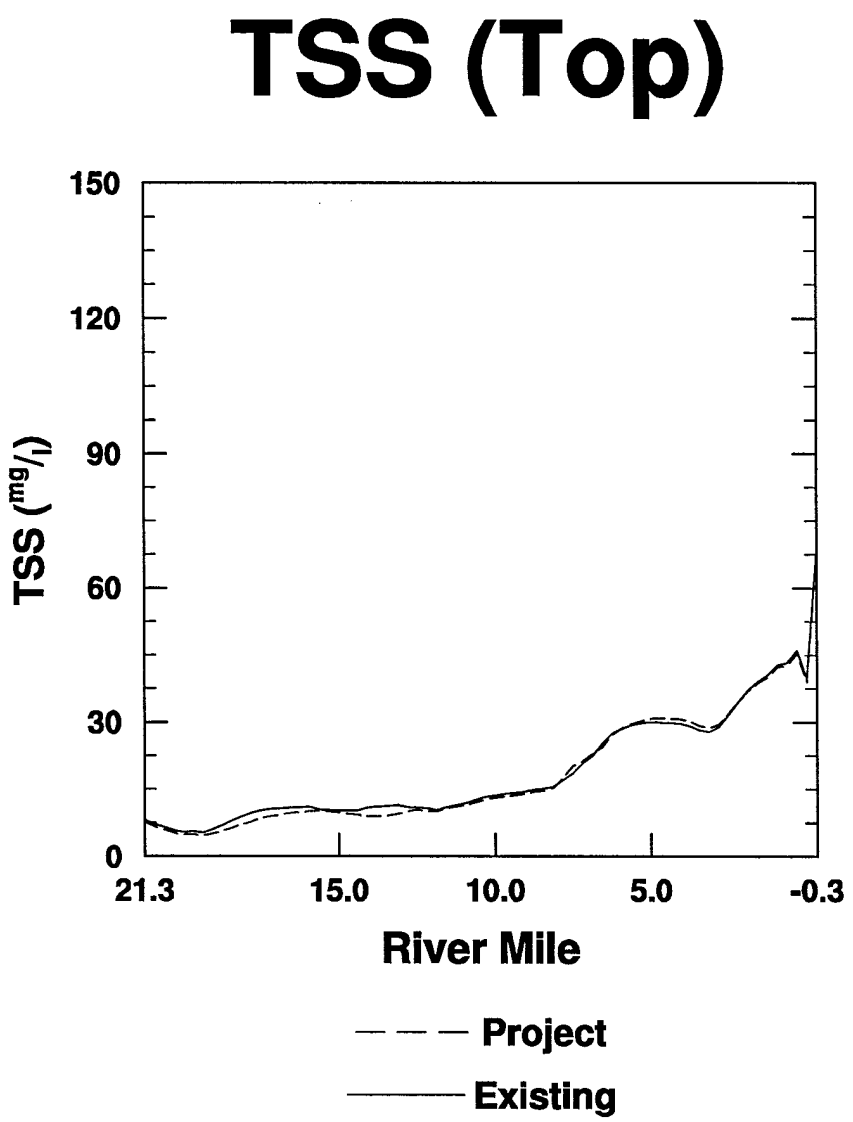


Figure 28. Surface TSS comparison, September 6, 1994

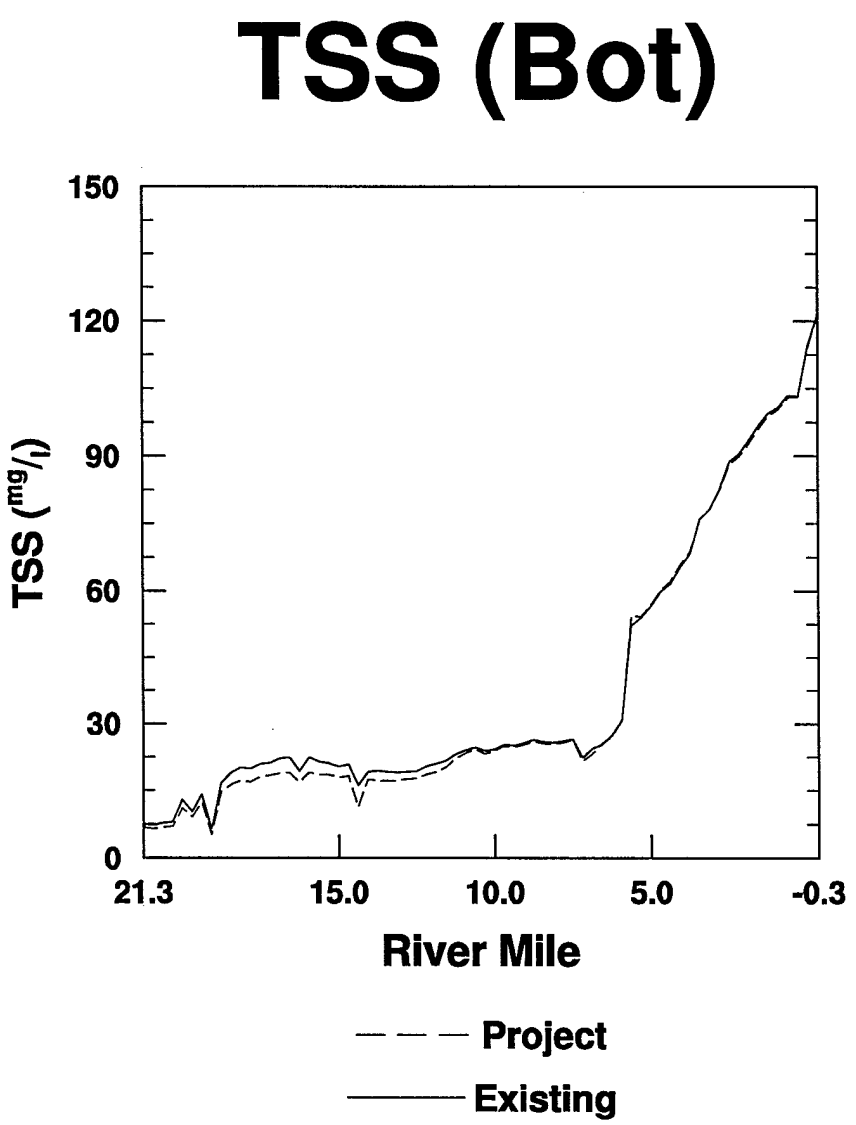


Figure 29. Bottom TSS comparison, September 6, 1994

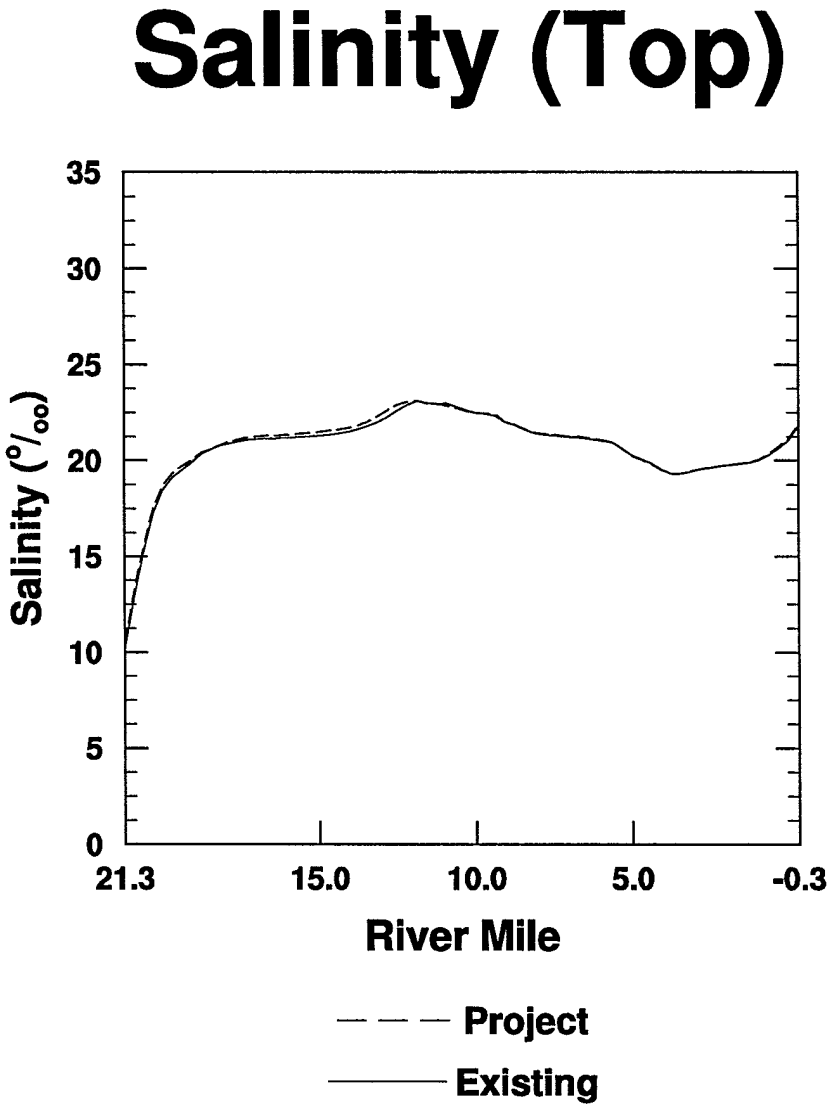


Figure 30. Surface salinity comparison, August 10, 1994

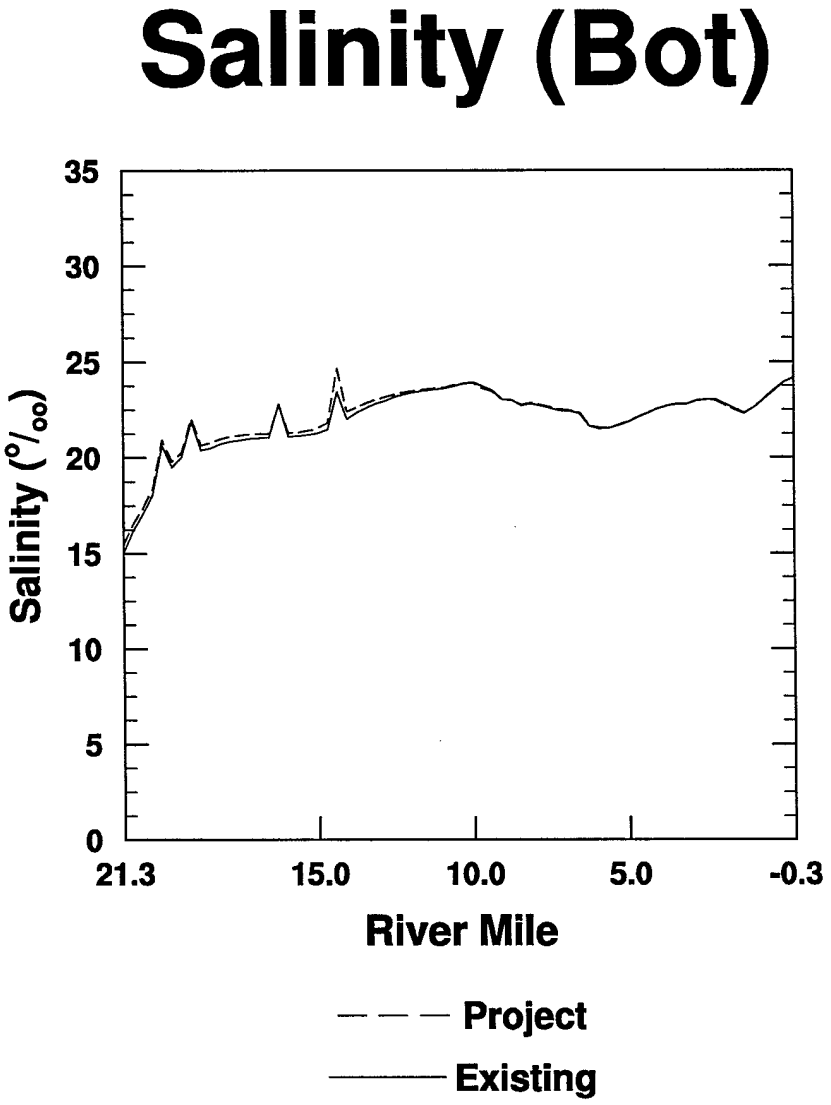


Figure 31. Bottom salinity comparison, August 10, 1994

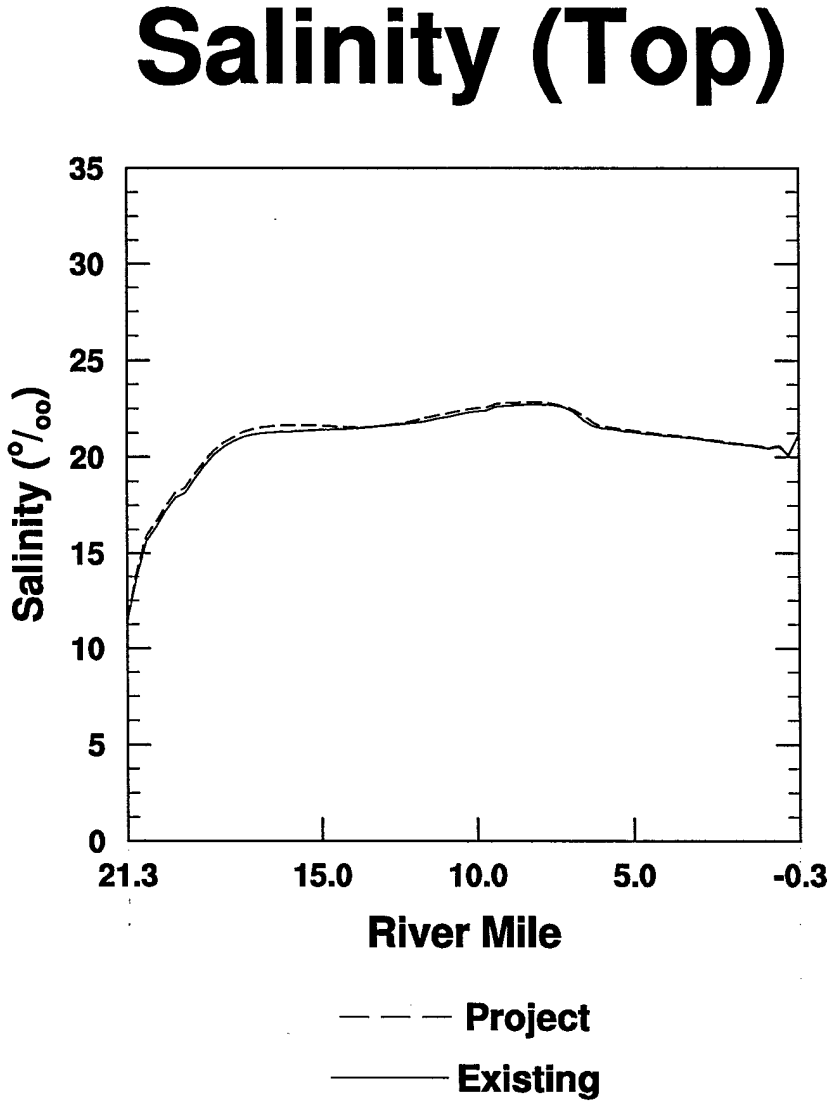


Figure 32. Surface salinity comparison, September 6, 1994

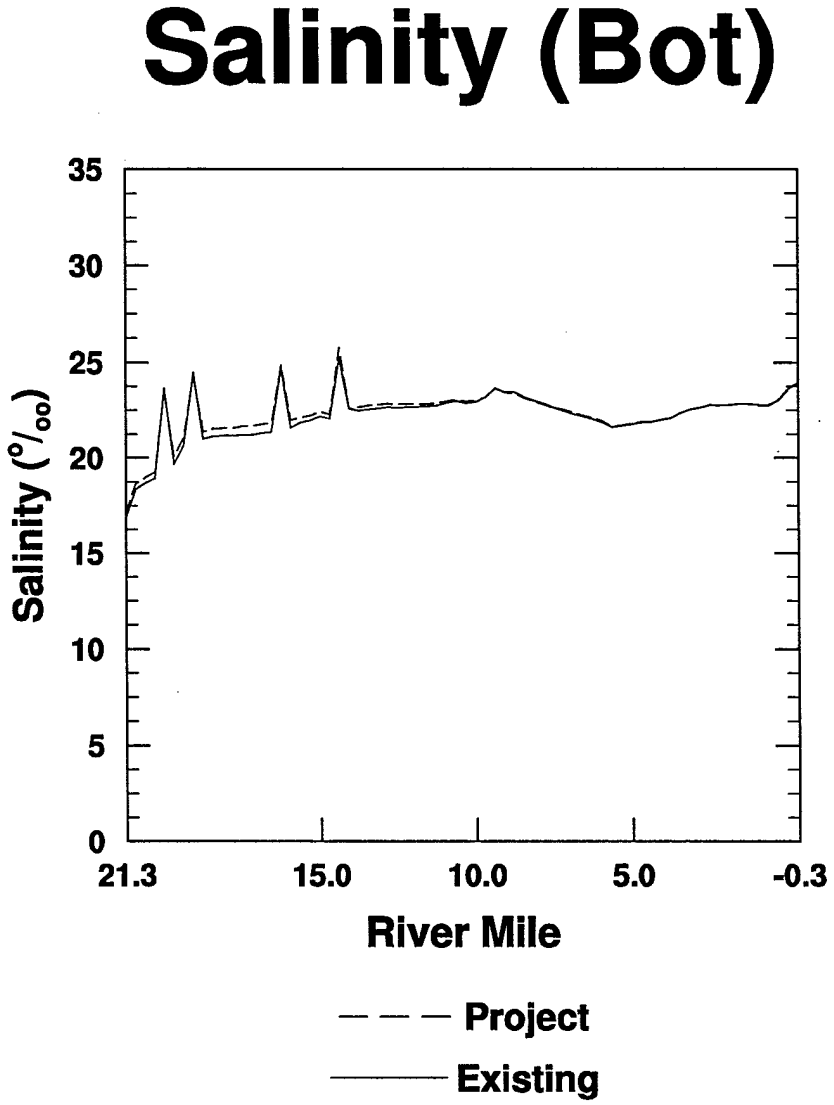
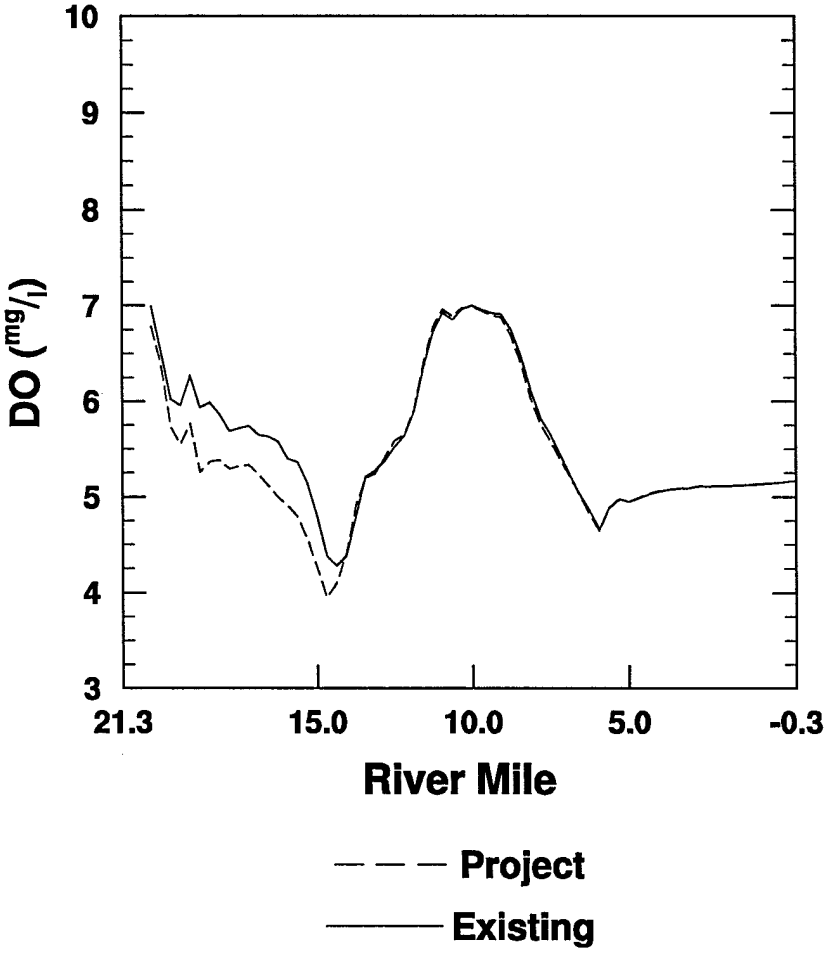


Figure 33. Bottom salinity comparison, September 6, 1994

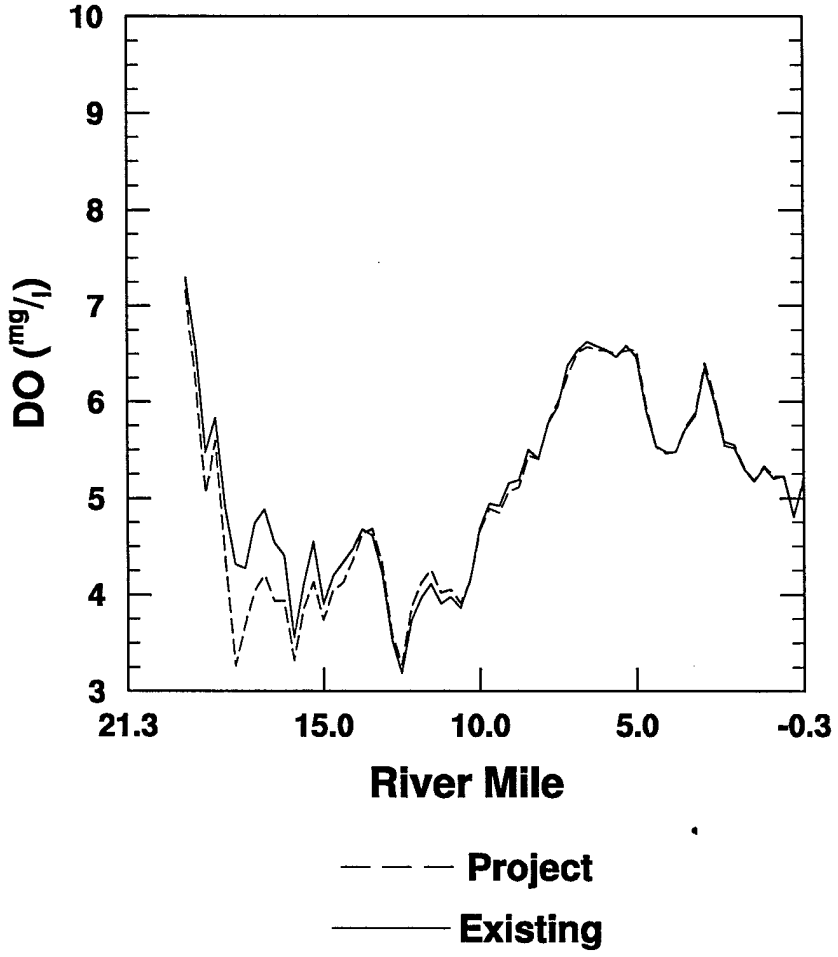
Dissolved Oxygen (3 m)



Day 222.681

Figure 34. DO comparison, August 10, 1994

Dissolved Oxygen (3 m)



Day 249.242

Figure 35. DO comparison, September 6, 1994

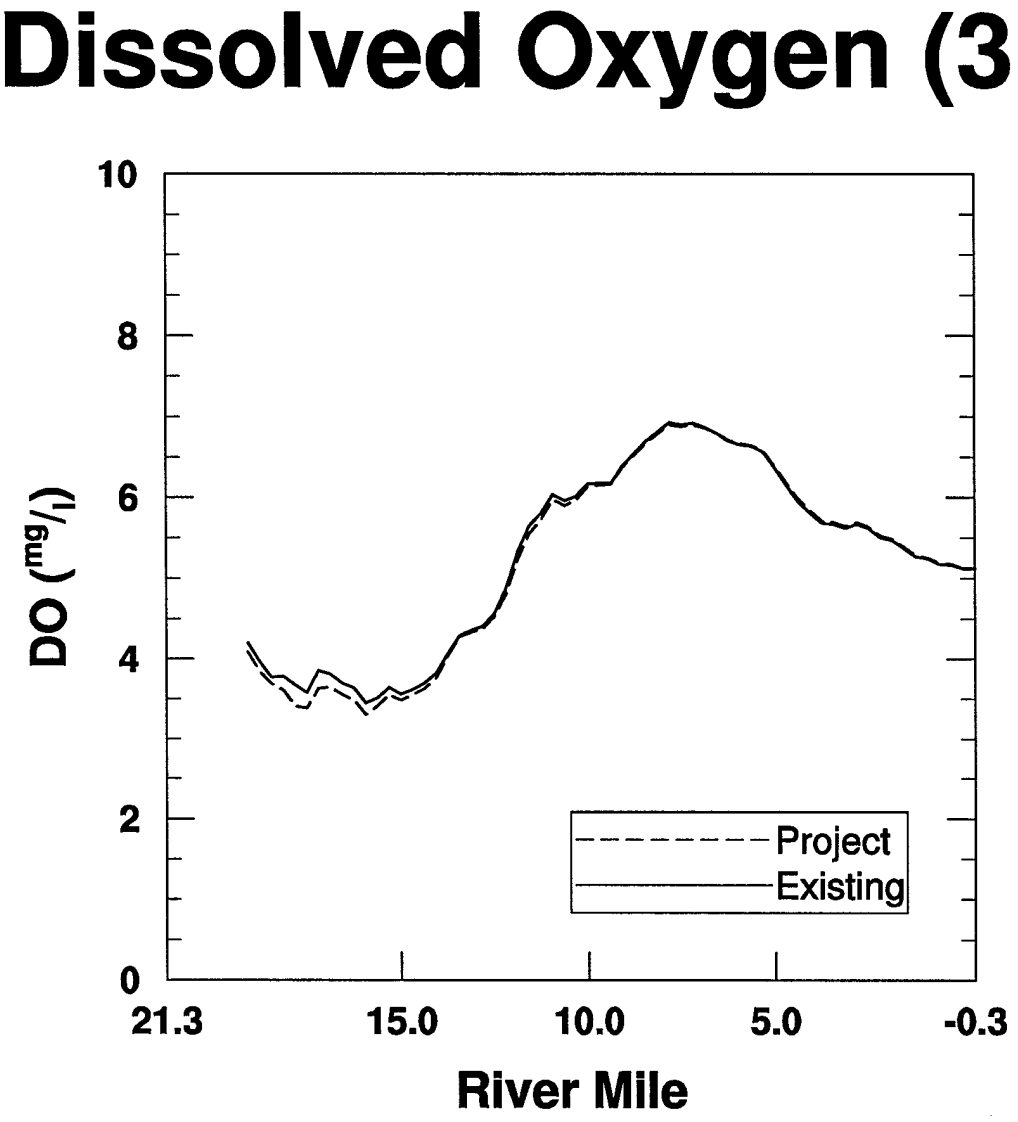


Figure 36. Average DO comparison, August 1 - September 30, 1994

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1998	Final report

4. TITLE AND SUBTITLE
Water Quality Modeling for the Napa River 100-Year Flood Control Project

5. FUNDING NUMBERS

6. AUTHOR(S)
Ross W. Hall, Mark S. Dortch

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
Miscellaneous Paper EL-98-2

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Engineer District, Sacramento
1325 J Street
Sacramento, CA 95814-2922

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

The objective of the study was to compare dissolved oxygen (DO), and other water quality variables between existing and project conditions. The two-dimensional hydrodynamic and water quality model CE-QUAL-W2 was selected for the study. Constituents simulated included temperature, total suspended solids (TSS), salinity, DO, and biochemical oxygen demand (BOD). The study consisted of two steps: (1) calibration to existing conditions and (2) comparison of existing and project conditions. The period of simulation extended from July 1 through September 30, 1994. The 100-year flood control project increases the channel conveyance needed to carry flood flows. Increased conveyance is achieved by excavating and widening the channel above the mean-tide level, and creation of a floodway through the city. Temperatures between existing and project conditions were equivalent except for an increase of less than 1 °C in the project reach. TSS and salinity comparisons revealed no differences. DO comparison revealed a DO decrease of less than 1 g m^{-3} in the proposed project reach.

14. SUBJECT TERMS
Biochemical oxygen demand
Napa River (Calif.)
Water -- Dissolved oxygen
Water quality -- California -- Testing

15. NUMBER OF PAGES
56

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		